DOCUMENT RESUME

ED 304 678 CS 009 567

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TITLE Interventions to Teach Thinking Skills: Investigating the Question of Transfer. Elementary Subjects Center Series No. 6.
INSTITUTION Michigan State Univ., East Lansing. Inst. for Research on Teaching.
SPONS AGENCY Office of Educational Research and Improvement (ED), Washington, DC.
PUB DATE Dec 88
CONTRACT G0098C0226
NOTE 77p.
AVAILABLE FROM Institute for Research on Teaching, College of Education, 252 Erickson Hall, Michigan State University, East Lansing, MI 48824 ($6.25).
PUB TYPE Reports - Evaluative/Feasibility (142)

EDRS PRICE MF01/PC04 Plus Postage.
DESCRIPTORS *Critical Thinking; Elementary Education; *Learning Strategies; Problem Solving; Productive Thinking; Skill Development; *Transfer of Training
IDENTIFIERS *Thinking Skills

ABSTRACT

This review examines 12 programs designed for use in classrooms to develop "general thinking skills" used in learning and problem-solving situations inside and outside classrooms. Analysis of program features focuses on the extent to which each program shows promise in helping students transfer the skills they develop through completing program exercises to other learning situations. It is argued that programs with multiple goals are more likely to promote transfer of skills than those that promote the single goal of particular skill development. Thus, programs that also focus on three additional goals (developing metacognitive awareness and strategies; conditional knowledge of contexts for knowledge and skill use; and attitudes and dispositions conducive to using the skills) show more promise. Other program features that increase the likelihood of transfer are (1) program materials are content related; (2) teaching methods include a high degree of teacher mediation; (3) transfer of skills is directly taught; and (4) teachers are trained to use the materials. It is concluded that interventions to teach thinking skills can be useful tools, but they need to be used in conjunction with occasions for students to develop and use higher order thinking in subject area learning. (Forty-eight references are attached.) (Author)

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ED304678

Elementary Subjects Center
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INTERVENTIONS TO TEACH THINKING SKILLS: INVESTIGATING THE QUESTION OF TRANSFER

Cheryl Rosaen

Center for the Learning and Teaching of Elementary Subjects

Institute for Research on Teaching
College of Education
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Published by

The Center for the Learning and Teaching of Elementary Subjects
Institute for Research on Teaching
252 Erickson Hall
Michigan State University
East Lansing, Michigan 48824-1034

December 1988

This work is sponsored in part by the Center for the Learning and Teaching of Elementary Subjects, Institute for Research on Teaching, Michigan State University. The Center for the Learning and Teaching of Elementary Subjects is funded primarily by the Office of Educational Research and Improvement, U.S. Department of Education. The opinions expressed in this publication do not necessarily reflect the position, policy, or endorsement of the Office or Department (Cooperative Agreement No. G0098C0226).

Center for the Learning and Teaching of Elementary Subjects

The Center for the Learning and Teaching of Elementary Subjects was awarded to Michigan State University in 1987 after a nationwide competition. Funded by the Office of Educational Research and Improvement, U.S. Department of Education, the Elementary Subjects Center is a major project housed in the Institute for Research on Teaching (IRT). The program focuses on conceptual understanding, higher order thinking, and problem solving in elementary school teaching of mathematics, science, social studies, literature, and the arts. Center researchers are identifying exemplary curriculum, instruction, and evaluation practices in the teaching of these school subjects; studying these practices to build new hypotheses about how the effectiveness of elementary schools can be improved; testing these hypotheses through school-based research; and making specific recommendations for the improvement of school policies, instructional materials, assessment procedures, and teaching practices. Research questions include, What content should be taught when teaching for conceptual understanding and higher level learning? How do teachers concentrate their teaching to use their limited resources best? and In what ways is good teaching subject matter-specific?

The work is designed to unfold in three phases, beginning with literature review and interview studies designed to elicit and synthesize the points of view of various stakeholders (representatives of the underlying academic disciplines, intellectual leaders and organizations concerned with curriculum and instruction in school subjects, classroom teachers, state- and district-level policymakers) concerning ideal curriculum, instruction, and evaluation practices in these five content areas at the elementary level. Phase II involves interview and observation methods designed to describe current practice, and in particular, best practice as observed in the classrooms of teachers believed to be outstanding. Phase II also involves analysis of curricula (both widely used curriculum series and distinctive curricula developed with special emphasis on conceptual understanding and higher order applications), as another approach to gathering information about current practices. In Phase III, test models of ideal practice will be developed based on what has been learned and synthesized from the first two phases.

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Abstract

This review examines 12 programs designed for use in classrooms to develop "general thinking skills" used in learning and problem-solving situations inside and outside classrooms. Analysis of program features focuses on the extent to which each program shows promise in helping students transfer the skills they develop through completing program exercises to other learning situations. It is argued that programs with multiple goals are more likely to promote transfer of skills than those that promote the single goal of particular skill development. Thus, programs that also focus on three additional goals (developing metacognitive awareness and strategies; conditional knowledge of contexts for knowledge and skill use; and attitudes and dispositions conducive to using the skills) show more promise. Other program features that increase the likelihood of transfer are (a) program materials are content-related; (b) teaching methods include a high degree of teacher mediation; (c) transfer of skills is directly taught; and (d) teachers are trained to use the materials. It is concluded that interventions to teach thinking skills can be useful tools, but they need to be used in conjunction with occasions for students to develop and use higher order thinking in subject area learning.

INTERVENTIONS TO TEACH THINKING SKILLS: INVESTIGATING THE QUESTION OF TRANSFER

Cheryl Rosaen[1]

The Question of Transfer

In recent years a wide variety of instructional programs have been developed specifically for the purpose of improving students' learning and thinking skills. Many of these programs emphasize developing students' ability to focus on and effectively use thinking processes, with less emphasis on the content or problem being solved. While there is some evidence of internal success in programs that develop general thinking skills and strategies, further investigation is needed to determine whether isolated skill development helps students to apply abilities and strategies beyond the program exercises; that is, to what extent do students develop the disposition and capabilities to use the skills they develop through program exercises in other learning situations or to solve everyday problems?

The research agenda in the Center for the Learning and Teaching of Elementary Subjects focuses on studying ways to improve higher order thinking and problem solving in five subject matter areas: social studies, mathematics, literature, science, and the arts. As part of the Center's broad efforts to examine the nature of instruction that promotes higher order thinking and problem solving in the subject matter areas, this paper discusses the role thinking skills programs might play in improving learning and thinking in the

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subject areas. Specifically, this review examines 12 programs designed for use in elementary classrooms to develop "general thinking skills" used in learning and problem solving situations both inside and outside classrooms. Analysis of the programs focuses on the extent to which each program shows promise in helping students transfer the skills they develop through completing program exercises to other learning situations.

The ability to transfer general skills and strategies requires having the capacity and disposition to use and apply them to learn and think in the content areas, and in this sense is the ability to use "higher order" thinking (Resnick, 1987). An underlying assumption is that students must develop intellectual resources (e.g., thinking skills and strategies), and the resources must be accessible so that they can draw on and use them in learning situations (Prawat, 1988). Moreover, in a comprehensive review of the literature that relates to the interaction between domain-specific and strategic knowledge, Alexander and Judy (in press) identify and explain several ways in which learners' developing domain and strategic knowledge shape each other. Among several hypotheses developed in the review, they make the case that perceiving the relatedness in domain and strategic knowledge across tasks and across domains seems to characterize competent performance. Thus, they argue, acquiring knowledge seems to enable learners to abstract or represent mentally a given problem, to classify problems on the basis of their underlying structures, and to use the perceived relatedness to guide their performance. Given these apparent relationships among declarative, strategic, and conditional knowledge, it is important to consider how programs in "general thinking skills" contribute to subject matter learning.

In this review it is argued that a "promising" program is one that not only helps students develop specific thinking skills, but also helps them

deliberately generalize and apply the thinking principles they learn through program exercises to further their learning in the subject areas and to further their everyday reasoning abilities. In addition to reviewing available evaluation data for each program regarding its effectiveness, particular attention is paid to identifying and describing program features that increase the likelihood that students will develop the disposition and skill to draw on the intellectual resources they develop.

Program Selection and Analysis

The 12 programs reviewed (shown in Table 1) were chosen because they are typical of efforts to improve general thinking skills and strategies, they have been widely used, and there is some information available about their effectiveness. In keeping with the Center's focus on elementary teaching and learning, this review is limited to those programs that are suited to students of elementary age.

Discussion of the 12 programs is divided into two major sections that reflect differences in program goals. As shown in Table 1, the four programs listed at the top (Structure of the Intellect, Cognitive Research Trust, Think About, and Science . . . A Process Approach) focus on a single goal: to develop particular thinking skills that will improve thinking ability (see Goal A). The seven programs listed at the bottom of Table 1 (Instrumental Enrichment, Productive Thinking Program, Odyssey, Talents Unlimited, Philosophy for Children, Reciprocal Teaching, Expository Writing Program, and LOGO) focus on multiple goals. In addition to trying to help students develop particular thinking skills (as programs in the first group strive toward), these programs take on additional goals that may include one or more of the following: developing metacognitive awareness and strategies (Goal B), developing conditional

Table 1: Overview of Program Goals

	Programs Reviewed	Goal A: Develop Cognitive Abilities	Goal B: Develop Metacognitive Awareness and Strategies	Goal C: Develop Conditional Knowledge of Contexts for Use of Knowledge and Skills	Goal D: Develop Attitudes and Dispositions to Use Skills
Group I: Programs with Single Goals	Structure of the Intellect (SOI)	x			
	Cognitive Research Trust (CoRT)	x			
	ThinkAbout	x			
	Science...A Process Approach (SAPA)	x			
Group II: Programs with Multiple Goals	Instrumental Enrichment (IE)	x	(x)		(x)
	Productive Thinking Program	x	x		(x)
	Odyssey	x	(x)	(x)	(x)
	Talents Unlimited (TU)	x	(x)	(x)	(x)
	Philosophy for Children	x	(x)	(x)	(x)
	Reciprocal Teaching	x	x	(x)	(x)
	Expository Writing Project (EWP)	x	x	(x)	
	LOGO	x	x		

Key: x Primary Goal of Program
(x) Secondary Goal of Program

knowledge about contexts in which knowledge and skills might be used (Goal C), and developing attitudes and dispositions to use the skills (Goal D).

For each program the following descriptive information is given: the underlying assumptions and goals of the program, the methods and materials used, the student population for which it is intended, the qualifications teachers need to implement the program, and evaluation efforts and information about its effectiveness. Throughout this discussion, it will be argued that programs with multiple goals (shown on the bottom half of Table 1) are more likely to promote transfer of skills than those that promote the single goal of particular skill development. Moreover, illustrations are provided to show that programs with the following characteristics are more likely to promote transfer or higher order thinking in the content areas and in everyday reasoning: (a) program materials are content-related, (b) methods include a high degree of teacher mediation, (c) transfer of skills is taught directly, and (d) teachers are explicitly trained to use the materials. These features are summarized for each program in Table 2 and discussed in detail throughout the review.

In the concluding section of the review, features of more promising programs are highlighted, with emphasis given to ways in which these features promote transfer. In addition, evaluation issues are identified and discussed.

Programs Designed to Improve Cognitive Abilities

Four programs are reviewed in this section: The Structure of the Intellect Program (SOI), Cognitive Research Trust (CoRT), ThinkAbout, and Science . . . A Process Approach (SAPA). These four programs share a common single focus on developing particular skills that will promote better thinking, with the overall goal of developing and improving the learner's capacity to think and learn. Program developers assume that improved capacity will allow students to engage in and monitor more complex cognitive activity as they

Table 2: Summary of Program Characteristics that increase Likelihood of Transfer of Skills to Other Contexts

	Programs Reviewed	Program Goals				Materials Used		Intended Degree of Teacher Mediation			Transfer of Skills		Teacher Training		Program Evaluation Results		Characteristics Show Increased Likelihood of Transfer
		A	B	C	D	Content Free	Subject Matter Related	Low	Medium	High	Assumed	Taught	Through Materials	Explicit Training Required	Some Immediate Gains Shown	Transfer Shown	
Group I: Programs with Single Goals	Structure of the Intellect (SOI)	x				+		+			+		+		+		
	Cognitive Research Trust (CoRT)	x				+			+		+		+		+		
	ThinkAbout	x					+			+	+		+		+		
	Science...A Process Approach (SAPA)	x					+			+		+	+		+		
Group II Programs with Multiple Goals	Instrumental Enrichment (IE)	x	(+)		(x)	+				+		+		+	+		+
	Productive Thinking Program	x	x		(x)	+				+	+		+		+		+
	Odyssey	x	(x)	(x)	(x)		+			+	+			+	+	+	+
	Talents Unlimited (TU)	x	(x)	(x)	(x)		+			+		+		+	+		+
	Philosophy for Children	x	(x)	(x)	(x)		+			+		+		+	+		+
	Reciprocal Teaching	x	x	(x)	(x)		+			+		+		+	+	+	+
	Expository Writing Project (EWP)	x	x	(x)			+			+		+	+		+		+
	LOGO	x	x				+			(+)	+			(+)	(+)	(+)	(+)

Key: x Primary Goal of Program
(x) Secondary Goal of Program

\+ Program has characteristic
(+) Program shifting toward developing characteristic

Goal A: Develop Cognitive Abilities
Goal B: Develop Metacognitive Awareness & Strategies
Goal C: Develop Conditional Knowledge
Goal D: Develop Attitudes and Dispositions

Shaded portions indicate characteristics important to transfer of skills to other contexts

encounter future learning experiences in or out of school. The particular skills on which each program focuses are summarized in Table 3 and elaborated in the sections below.

The four programs are further grouped according to similarities in their methods and materials used. The first two (SOI and CoRT) are programs that develop abilities through content-free or generic materials. The focus of teacher and student attention is limited to practice of particular skills with little emphasis on developing awareness of how and when to use particular strategies. The second two programs (ThinkAbout and SAPA) develop abilities through subject matter-related materials, but emphasize skill development over knowledge development. Moreover, these two programs have a higher degree of teacher mediation than the first two, where the teacher's role is to foster reflective thinking by providing opportunities for students to engage in reflective thinking, providing appropriate guidance and support for developing effective thinking strategies, and helping students become independent learners and thinkers. Thus, the second two programs contrast with the first two in the amount and nature of the discourse surrounding the exercises offered in the program. Contrasts in program features, summarized in Table 2, will be discussed in greater detail in the sections below.

Programs That Develop Abilities Using Generic Materials

The two programs reviewed in this section work toward an overall goal of developing particular thinking skills through the use of generic or content-free materials. It is thought that this allows students to focus more specifically on skill development without the student's prior knowledge level interfering with efforts to develop skills. It is also assumed that successful improvement of target skills will result in students becoming better thinkers.

Table 3: Overview of Thinking Skills Emphasized in Programs with Single Goal

Group I: Programs with Single Goal	Goal A: Cognitive Abilities Developed as Primary Program Goals
Structure of the Intellect (SOI)	120 separable intellectual skills are derived from crossing five mental operations (cognition, memory, evaluation, convergent production, divergent production) with four contents (figural, symbolic, semantic and behavior) and six productions (units, classes, relations, systems, transformations, implications).
Cognitive Research Trust (CoRT)	Perceptual tools taught by generating ideas, reflecting on perceptions, organizing both, prioritizing, considering other points of view. Focuses on analytic and logical skills needed for reflecting on perceptions. Creative thinking.
ThinkAbout	13 Basic Reasoning Skills in finding alternatives, collecting information, finding patterns, classifying, using criteria, reshaping information, judging information. 65 specific skills in math, language arts, study skills. "Tips and challenges" on memory improvement, goal setting.
Science...A Process Approach (SAPA)	Learn processes involved in scientific work: process as an intellectual skill, especially as it relates to processing information.

Structure of Intellect Program. The Structure of Intellect Program was developed by the SOI Institute, a nonprofit educational corporation located in California. The institute provides tests, diagnostic services, prescriptions of exercises designed to address weaknesses identified by the tests, and exercises to carry out the recommendations (Nickerson, Perkins, & Smith, 1985). Since evaluation activities have included students in all elementary grades through eighth grade, it is assumed that is the target student population. The SOI Program (see Table 3) is based on the idea of remediation of deficiencies in abilities. Remediation decisions and prescriptions are based on Guilford's (1967) structure-of-intellect theory. This theory assumes that a total of 120 separable intellectual skills can be derived from crossing five mental operations--cognition, memory, evaluation, convergent production, and divergent production; with four contents--figural, symbolic, semantic, and behavior; and six products--units, classes, relations, systems, transformations, and implications (Sternberg & Bhana, 1986). Support for this theory, offered in the form of factor analysis, has been criticized for its statistical techniques, but still remains the foundation upon which the program is based (Nickerson et al., 1985).

Other program features are summarized in Table 2 and discussed below. Materials in the program are developed most extensively for 25 of the 120 intellectual skills, which are considered most relevant to school subject areas. Deficiencies in intellectual skills are identified before the program begins through the use of the Structure of Intellect-Learning Abilities test (SOI-LA). Exercises are prescribed for deficient areas (as identified by the test), and students then take a posttest. Because of the individually prescribed nature of the program, students will experience different aspects of what the program has to offer (Sternberg & Bhana, 1986). The exercises are test-like in nature,

and are content-free in that the object of thought and focus is on developing the skill, not the content. In addition, the materials are "teacher proof" in the sense that the test (SOI-LA) makes decisions about prescription (not the teacher), and the training program for teachers is "relatively regimented" (Sternberg & Bhana, 1986, p.65). Thus, the teacher's role is reduced to implementation, with little variation expected in the way particular training exercises are implemented across students.

Studies on the effectiveness of the SOI program are limited to those carried out by the SOI Institute. They address three issues: (a) the reliability and validity of SOI instruments, (b) the extent to which training produces intellectual growth, and (c) the impact of SOI instruction on school performance and other work (Nickerson et al., 1985). Studies in the first area show problems with statistical reliability and show different factors as important across studies. Studies in the second area show gains, but the intellectual growth is measured by SOI instruments, which raises the issue as to whether the program teaches to the test, especially since the exercises are so similar in format to test items. Only two studies are available for the third area. One showed student gains in mathematics but not reading. The second showed gains in 18 of 26 factors addressed, but there was no control group. The transfer that is indicated seems to apply more to transfer to other tests that measure skills similar to those measured by SOI instruments.

Thus, there are some indications of gains in intellectual growth and gains in application of abilities to school subjects, but the studies are not clearly reported, nor are the designs of the studies adequate (Sternberg & Bhana, 1986). No information is provided as to whether students enjoy or are challenged by the exercises. Particularly for use with young children, the format (completing test-like instruments with little or no interaction) may lack

stimulation. There are no direct efforts made by the teacher to encourage transfer to school subject areas or other situations, which greatly reduces the likelihood of transfer.

Cognitive Research Trust. Cognitive Research Trust (CoRT) was developed by Edward deBono for use with people of all ages spanning ages five years through adult. Its commercially available materials are widely used in more than 5,000 schools in Venezuela, England, Scotland, Wales, Eire, Australia, New Zealand, Canada, Spain, Malta, and Nigeria (deBono, 1985). The program rests on the assumption that of the two basic thinking stages, perception and analysis, lack of precise perception is most often the cause of poor thinking (deBono, 1985). DeBono further claims that people do not generally lack perceptual skills. Instead, they simply are not aware of their importance, are not used to using them, and therefore do not. Two main purposes of the exercises and activities in the program (see Table 3) are to help people learn simple tools for directing their attention appropriately in thinking and to provide ways for them to practice using the tools so their use becomes automatic (Chance, 1986). Transfer of the tools is expected to apply more specifically to thinking in everyday situations than to school tasks, although deBono (1985) also claims that developing automaticity in using the tools will eventually promote clearer thinking in all areas.

Table 2 includes a summary of additional program features. Materials in the program for people age 12 and over are divided into six units (Breadth, Organization, Interaction, Creativity, Information and Feeling, and Action). Materials are content-free, based on the assumption that it is helpful to students to remove content knowledge as a potential obstacle in the thinking process so that they can concentrate more fully on developing perceptual tools. These materials have been used for children slightly younger (ages 9 through 11) if their verbal skills are sufficient to benefit from the materials.

A "Thinking Course for Juniors" is available for children ages 5 through 12. The course for younger children uses visual items to compensate for the lesser verbal skills expected of this age group, and centers around designs or inventions. Children draw designs (e.g., a chocolate-making machine), make partial drawings, criticize completed drawings, or illustrate situations in a cartoon format. The exercises are provided to practice thinking, with no direct instruction in thinking provided (Polson & Jeffries, 1985). In addition, there is a collection of games called Think Links intended to facilitate thinking practice. The games vary for different age groups.

The 6 units in the regular CoRT program consist of 60 lessons. The program is used most often with children spanning the ages 9 through 12 (Chance, 1986). Presumably the format for conducting the lessons is similar to that in the Thinking for Juniors version. Typically, students will complete one CoRT lesson weekly that lasts between 30 and 50 minutes. According to Chance (1986), each lesson follows the sequence: Introduction (describing the tool to be learned), Practice (small group practice using the tool), Process (class discussion of the tool), Principles (group work designed to focus on the nature of the tool), and Project (additional practice items that are completed if time permits).

The teacher's role in the learning process is to facilitate practice using the perceptual tools. For example, CoRT teachers are directed to keep the discussion narrowly focused on one tool at a time. In addition, they are directed not to review tools previously practiced during a lesson on a new tool. This is based on the assumption that such overlap will just confuse students, and that purposeful practice of one skill at a time is most likely to develop the desired automaticity in perception that is needed for better thinking (Chance, 1986). Teachers may use their judgement to vary activities and include role playing, dramatization, drawing and writing, but they are cautioned to keep the

focus on the tool being practiced. Like SOI, program materials are highly structured, and it is assumed that teachers will be highly motivated to use the materials provided to learn about the program content and optimal ways to implement it.

Despite the program's use for over 10 years, there is no published information regarding its effectiveness, and only deBono's informal research methods have been used to assess the effectiveness of the six instructional units in the regular CoRT program--information observations, informal studies incorporated into an instructional program, unpublished notes (see Polson & Jeffries, 1985). In addition, many of the populations for studies conducted vary on the extent to which the program materials were actually used with students. Nevertheless, results show transfer of those performances in which students were specifically trained to other tasks similar to those in the CoRT activities. In addition, students do typically generate more ideas regarding issues that require abstraction and a balanced view of problems. These findings do not, however, demonstrate transfer to activities less similar to CoRT exercises, nor do they show transfer to thinking in school subject areas (Nickerson et al., 1985).

Others who have reviewed the CoRT program reveal additional problems. For example, Polson and Jeffries (1985) point out that CoRT materials contain a great deal of overlap across thinking tools to be developed. For instance, goal formation is covered in three lessons (Define the Problem, Target, and purpose). Since deBono explicitly directs teachers not to discuss ways in which tools across lessons interrelate, this might confuse students, and does not provide guidance for them to interpret how and when to use the apparently separate tools in everyday contexts. Chance (1986) notes that student and teacher response to the program is not always positive. One objection is the

use of acronyms (e.g., PMI, CAF, OPV) to name different tools and another that students often feel they already know how to use the tools they are practicing. DeBono's counterargument is that students may know them, but they have not learned to use them. Finally, the regimented pattern that the lessons follow becomes monotonous for the students. DeBono acknowledges this problem, but instead of restructuring the lessons, he recommends increasing the tight focus on the tool during each lesson. This does not seem a likely relief from monotony.

Programs That Develop Abilities Using Subject Matter-Related Materials

Two programs are reviewed in this section: ThinkAbout and Science . . . A Process Approach. Each of these programs identifies developing thinking skills as an important outcome, and each uses subject matter-related materials as a means to develop specific abilities. Through the use of such materials, there is more direct emphasis on helping students see how thinking skills apply to school subjects than with the SOI and CoRT programs that use content-free materials. However, these programs clearly place a lower priority on subject matter learning than on skill development. Unlike SOI and CoRT where the degree of teacher mediation is minimal, these two programs place greater importance on the role of dialogue and interaction in the learning process, so the teacher has a central role in helping students develop abilities.

ThinkAbout

The goal of the ThinkAbout Program is to develop independent learners and problem solvers. It was developed from 1976-78 for fifth-and sixth-grade students by the Skills Essential to Learning Project, a consortium of over 40 American and Canadian state and provincial agencies (Nickerson et al., 1985). It is assumed that students will develop effective problem solving skills by

seeing and discussing how others solve problems and by being motivated to engage in problem-solving activities.

The program identifies thirteen basic reasoning skills (e.g., finding alternatives, collecting information, finding patterns, classifying, using criteria, reshaping information, judging information; see Table 3). A total of sixty 15-minute video programs focus on the 13 basic skills, devoting about two to six programs to each skill. The program also identifies about 65 specific skills in mathematics, language arts, and study skills which the curriculum materials are designed to reinforce. Nine categories organize the 65 skills: reading; writing; listening; speaking/discussion/presenting; viewing and observing; graphs, maps, and scale drawings; measurement; computation; and study skills. Finally, a third emphasis is on "tips and challenges" designed to foster such things as memory improvement, goal setting, and handling anxiety (Nickerson et al., 1985).

Table 2 includes a summary of additional program features. The teacher's guide is extensive and outlines the overall purposes, rationale, content of the videotape, ways to prepare students for viewing the videotape, and specific suggestions for follow-up discussions and activities. Thus, discussion and interaction surrounding the problem-solving process is an important part of the program, and adequate teacher preparation is the key to successful implementation. The content of the videotapes blends posing problem-solving situations that may be related to school tasks (e.g., having to write a three-page biographical report on George Washington Carver) with a focus on a skill cluster (e.g., learning how to find alternatives in a problem-solving situation; see Nickerson et al., 1985). It is unclear as to how the program developers intend the students to connect the specific content-related skills with the 13 basic reasoning skills, or how they provide support for such connections to be made.

One evaluation of the first year of use as an entire series was conducted during the 1979-80 school year (Nickerson et al., 1985). Surveys, case studies and objective tests were administered in 241 classrooms. Standardized test scores show no clear differences in performance between students who did and did not participate in the program. In addition, implementation problems were identified. There were great differences across classrooms in how the ThinkAbout Program was tied to the rest of the curriculum and in how the teachers prepared to use it. Students sometimes perceived the use of television as a break from work instead of focusing on the goals of the program (to develop problem-solving abilities and become independent thinkers). Survey results showed that students and teachers generally liked the program, and teachers felt students' abilities improved. Thus it seems that the program may have been more successful in providing an enjoyable context for solving problems and less successful in helping students develop specific skills or in helping them apply those skills to school subjects.

Science . . . A Process Approach

Science . . . A Process Approach (SAPA) was developed for use with grades K through 6 by the Commission on Science Education of the American Association for the Advancement of Science. The main goal of the program is to help students learn the processes involved in scientific work (see Table 3). Underlying the goal of teaching scientific processes is Gagné's distinction among three types of processes: (a) process as distinguished from content; (b) process as an activity in which a scientist normally engages; and (c) process as an intellectual skill, especially as it relates to processing information (cited in Nickerson et al., 1985). The third process is of particular interest in this review.

Scientific processes are organized in a behavioral hierarchy that is categorized into five stages within each grade level across grades K through 6. Table 2 outlines main features of the program. There are 105 modules that can each be taught in one class period. Materials and teacher instruction are provided for each module. As in ThinkAbout, the teacher materials outline objectives, rationale, instructional procedures, and methods. In the methods section, optional activities are provided to give the teacher maximum flexibility in deciding the best way to help students develop their use of the processes. In addition, the program provides supplementary materials for the teacher which includes a Program Guide (strategy descriptions) and Commentary for Teachers (self-instructional units on the processes of science). Presumably, the teacher will rely on the program materials for training. Implicit in the "hands-on" approach to scientific investigation (e.g., learning to observe by having the opportunity to observe and reflect on the experience) is the notion that, like teachers using ThinkAbout, teachers will play an integral role in helping students develop the skills needed to carry out scientific processes.

Instead of assuming transfer will occur through using materials that apply to a variety of contexts--as ThinkAbout developers assume--SAPA developers specifically direct teachers to give explicit attention to transfer. Each module includes "generalizing experiences" that require students to apply what they have learned in that module to other contexts (Nickerson et al., 1985). Some modules also provide instruction in mathematics and language skills, and the developers have as a clear goal that the effects of learning scientific processes will generalize to other subject areas (Gagné cited in Nickerson et al., 1985).

A series of experiments was conducted on the implementation of SAPA with fourth-and fifth-grade students. Results show that SAPA modules can show

gains, providing student progress is measured throughout instruction and further instruction is provided as needed (Nickerson et al., 1985). No transfer studies have been conducted to investigate the developers' claims of generalizability of effects of learning scientific processes to other domains over time.

Summary

The four programs reviewed in this section share an overall goal. They intend to teach skills that will improve thinking. There is some evidence to support the claim that they do have some short-term positive effects in the areas they target. There is not enough evidence, however, to predict the extent to which positive effects will make a difference in students' abilities to think long term or in their abilities to think about subject matter domains or everyday problems. Those issues clearly need further study.

Nevertheless, examination of the programs' similarities and differences reveal some lessons learned from these programs (see Table 2). Programs that address the issue of transfer of learning to other domains explicitly as part of their instruction (e.g., SAPA through "generalizing experiences") may have a better chance of succeeding than those that rely on transfer occurring because of the variety of contexts included in the materials (e.g., ThinkAbout). It appears that helping students become aware of the need for transfer and instances where transfer apply increases the likelihood that they would make such connections, compared to hoping the connections will be made (Sternberg, 1987). However, more information is needed to support this claim.

A second lesson to be learned is that the programs that use content-related materials (e.g., ThinkAbout, SAPA) seem to be more interesting to students and seem to do a better job helping students develop desired dispositions to use thinking skills. SOI and CoRT exercises are more test-like in nature, so that, even though students may become engaged in solving specific problems

posed in the exercises, there is less likelihood that they will generalize that such engagement applies to other contexts.

A third lesson is that active engagement in problem-solving and thinking activities does make a difference, and teachers play an important role in the process. SOI has not been very well received by students which may be due to its lack of emphasis on the role of the teacher. CoRT teachers are cautioned to limit the focus of discussion on perceptual skill development, and therefore bypass the opportunity to help students see ways in which skills can be used across experiences. The CoRT program is criticized by students as being monotonous, boring, and geared toward teaching skills students feel they already know. This may be partially due to the use of generic materials, or it may be due to the narrow focus of the discussions surrounding the materials. ThinkAbout and SAPA program developers see active discussion and reflection on the thinking process as key to the successes they claim for their program.

Finally, while all four programs claim that teacher preparation for using the program is important, they devote little energy (beyond providing detailed materials) to specific efforts to train teachers. Evaluation efforts have illuminated the tremendous difficulty involved in assessing student learning in the area of developing thinking skills. The same complexity exists in teaching such skills, and teachers should not be expected to be experts in teaching thinking simply by reading program materials. Perhaps if teachers were better trained in the underlying assumptions of the program, in carrying out effective implementation (e.g., thoughtful and lively discussions, diagnosing when students need further help), and in what to look for as evidence of student progress, some of the programs would provide better evidence to support their claims.

Programs With Multiple Goals

Eight programs are reviewed in this section: the Instrumental Enrichment Program (IE), the Productive Thinking Program, Odyssey, Talents Unlimited (TU), Philosophy for Children, Reciprocal Teaching, the Expository Writing Program (EWP), and LOGO. Like the first four programs reviewed, they share as a major goal a focus on developing specific skills. In addition to that goal, however, these programs take on one or more of the following goals: developing metacognitive awareness and strategies; developing conditional knowledge about contexts for knowledge and skill use; and developing attitudes and dispositions to use the skills (see Table 4 for a summary of each program's goals).

These eight programs are further divided into three groups according to the methods and materials they use. One group includes those programs with multiple goals that use generic materials (IE and the Productive Thinking Program). A second group includes three programs that focus on helping students apply the four broad program goals in an integrated fashion (Odyssey, TU, and Philosophy for Children). A third group includes those programs that help students work toward program goals through language--reading and writing--and symbol manipulation--mathematics (Nickerson et al., 1985). These programs are Reciprocal Teaching (reading comprehension), EWP (written composition), and LOGO (computer programming). A summary of these programs' characteristics is shown in Table 2, and discussion of ways in which these characteristics increase the likelihood of transfer of skills taught is included in the sections that follow.

Programs With Multiple Goals That Use Generic Materials

IE and the Productive Thinking Program are based on the assumption that direct and systematic training in the use of particular skills will improve thinking. They also share the assumption (along with SOI and CoRT) that it is

Table 4: Goals Overview for Programs with Multiple Goals

Group II Programs	Goal A: Develop Cognitive Abilities	Goal B: Develop Metacognitive Awareness & Strategies	Goal C: Develop Conditional Knowledge of Contexts for Knowledge & Skill Use	Goal D: Develop Attitudes and Dispositions to Use Thinking Skills
Instrumental Enrichment (IE)	Instruments designed to become more receptive and sensitive to stimuli: comparisons, categorization, analytic perception, inferences, interpreting information, problem solving, abstract reasoning, transverse relations, syllogisms, spatial visualization.	"Bridging" exercises encourage awareness of ways in which principles focused on in exercises relate to students' own experiences.		"Intrinsically interesting" exercises offer students the opportunity to feel the pleasure of succeeding at something that is inherently interesting. Students should develop attitudes and dispositions conducive to using and enjoying thinking skills.
Productive Thinking	5 Kinds of Thinking Skills: discovering and formulating problems, organizing and using information, generating ideas, evaluating and improving ideas, creating new perspectives.	Heuristics for generating and developing ideas (thinking guides). Strategic thinking: identify and analyze problems, monitor plans for their solution.		Value and enjoy thinking activity. Develop propensity to persist in searching for solutions to problems.
Odyssey	Target abilities: foundations of reasoning, understanding language, verbal reasoning, problem solving, decision making, inventive thinking, creativity.	Develop skilled intellectual performance by developing methods (appropriate ways of approaching tasks), knowledge (facts, concepts, principles used in the thinking process).	Discussions focus on teaching how and when to apply target skills. Skills used in variety of subject area contexts.	Skilled intellectual performance requires positive attitude. Learn to enjoy rewards of sense of curiosity, respect for others' opinions and enthusiasm for learning.
Talents Unlimited (TU)	5 Talent Areas: productive thinking, decision making, planning, forecasting, communication. These talent areas work in integrated fashion with academic talents to stimulate new thinking and develop knowledge and understanding.	Reflect on and discuss talent area models. Learn specific strategies for each talent area.	Weave knowledge and talents together as functioning teammates. Use variety of subject area contexts to apply talent areas.	Improve self-concept, confidence in and awareness of own talents. Be ready to use talent areas.
Philosophy for Children	30 Thinking Skills: philosophical or reasoning skills, inquiry skills, concept analysis skills, translation skills, syllogistic reasoning, creativity, verbal fluency, inferences, working with analogies.	Develop awareness of thinking process and "cognitive disposition" to use thinking skills.	Teach students to use thinking skills in a coordinated fashion. Focus on evaluating content and quality of philosophical dialogue.	Develop "cognitive disposition" to use thinking skills (to wonder, be critical, respect others, seek alternatives, to be inventive and inquisitive). Develop an interest in philosophical questions.
Reciprocal Teaching	4 Strategies to Foster Reading Comprehension Skills: summarize, question, clarify, predict.	Teach students to be aware of and manage metacognitive skills. Learn to monitor own comprehension.	Develop "deliberate effortful cognition." Understand how methods learned in reading comprehension influence the thinking process.	Help students value "deliberate effortful cognition."
Expository Writing Project (EWP)	Use nonlinear writing process as a tool for thinking and writing. Teach students to understand and use different text structures to comprehend and create text.	Students monitor own learning. Make thinking processes explicit during reading and writing. Understand and strategically use connections between reading and writing processes.	Become aware of and use own learning process to monitor one's understanding. Understand how and when to bring reading and writing together to comprehend and write about social studies content.	
LOGO	Develop Problem Solving Skills: subgoals formation, forward chaining, backward chaining, systematic trial and error, alternative problem representation, analogical reasoning.	Means-ends analysis, metacognitive strategies (debugging, trying new approach), reflective thinking.		

helpful to remove content knowledge as a potential obstacle in developing the thinking processes. The developers assume the use of generic materials helps students concentrate more fully on developing skills and strategies that will help them think better. Thus, the emphasis in the program is on process, not content. In both programs, the teacher plays an active role in the learning process. In this way they contrast with SOI and CoRT which give a fairly minimal role to the teacher.

The Instrumental Enrichment Program. The Instrumental Enrichment Program (IE) was developed by Reuven Feuerstein for use with "low-functioning" adolescents between the ages of 10 to 18 years. The term "low functioning" refers to an individual's lack of capacity to respond to new experiences. Thus, the goal of the program is to help socioculturally deprived adolescents (approximately age 11 on up) change their characteristic ways of dealing with information so that they are more receptive and sensitive to internal and external sources of stimuli, and thereby more readily able to learn from stimuli (see Table 4, Goal A). Presently, the program is used in Israel, the United States, Canada, and Venezuela (Nickerson et al., 1985).

A major assumption on which the program is built is that children learn how mature thinkers think by participating in interactions with adults, referred to as mediated learning experiences (MLE). Through everyday interactions with adults where there is a sufficient amount of social interaction surrounding experiences, children learn how to link, organize, relate, and transform relationships and also learn how to use various modalities of thinking (e.g., representational, inferential, hypothetical). Feuerstein hypothesizes that children who have not had these types of mediational learning experiences as part of their development are less able to understand academic material or learn new content because they do not perceive new content

analytically, nor do they elaborate new information and relate it to prior knowledge (Pressley, Cariglia, & Snyder, 1985).

Feuerstein further hypothesizes that deficiencies resulting from lack of mediated learning experiences can be remediated by appropriate exercises and that learners can therefore increase their capacity to learn after such remediation. The use of specific exercises is similar to methods used in SOI and CoRT to improve the capacity to think. Table 2 summarizes additional program features. Feuerstein developed a set of 15 exercises or instruments designed to provide a context for mediated learning. These paper-and-pencil exercises, ordered in increasing difficulty, are intended to expose the learner to cognitive skills used by effective learners, and to develop general concepts, skills, and attitudes that will make it possible for learners to learn more efficiently on their own (see Table 4, Goals B & D).

The teacher's role is to provide support by encouraging appropriate cognitive activities relevant to the materials. This support and interaction surrounding the experience may come during the introduction, the individual work time, class discussion time, or summary phase of the exercise. Ordinary teachers, with extensive training (at minimum a two-week workshop), can learn to use the materials and can only obtain the materials if they participate in the training. In addition, Feuerstein values the quality of the interaction between teachers and students more than the exercises themselves (Chance, 1986), which sharply contrasts with the teacher's role in SOI and CoRT, where the teacher merely implements program exercises.

The materials do not presuppose sophisticated content knowledge so that students can concentrate on the learning process. The object of thought is learning to see different kinds of relationships and connections, but not through subject matter-specific materials. Thus, exercises may include such

"content-free" tasks as connecting dots so that they conform to a model or identifying how everyday objects are oriented to one another on a drawing (Feuerstein, Jensen, Hoffman, & Rand., 1985). Students are to spend three to five hours per week completing the program over a two-year period.

Once students have worked through the set of 15 instruments, what can one expect about their transfer of skills they are developing through the exercises to their overall ability to learn? Two aspects of the program attempt to address this issue. First, each lesson focuses on one or two principles that have broad generality so that each lesson has a focal theme that can be related to themes in subsequent lessons (e.g., "when cues diminish, we have to change strategies"), and students are encouraged to relate one experience to another across the exercises (Bransford, Arbitman-Smith, Stein, & Vye, 1985). Again, this contrasts with CoRT where the teacher is discouraged from discussing with students how exercises in one area overlap or connect with others. Second, students are encouraged to "bridge" the principles brought out through the exercises to ways in which the principles apply to their own experiences (Table 4, Goal B).

These two aspects are dependent on the teacher mediating or supporting their occurrence. It is believed that finding examples of application of the principles across the exercises and in everyday experience will encourage transfer. The exercises themselves are invented with the intention of being "intrinsically interesting," thereby offering the opportunity for students to feel the pleasure of succeeding at accomplishing something that is inherently interesting. This addresses a secondary goal of the program, to develop attitudes and dispositions conducive to using thinking skills and enjoying their use (Table 4, Goal D). It is hoped that such experiences will provide the tools, confidence, and motivation for students to learn to solve problems independently (Bransford et al., 1985).

Feuerstein provides rich examples of individual cases where the IE Program has shown dramatic results (Chance, 1986). However, in a review of 38 studies of the program, Sternberg and Bhana (1986) report mixed results. Evaluation difficulties included variation in the subject populations (country, social class, age, intellectual level, educational level), amount of exposure to the program, and the extent to which particular instruments were actually used. In addition, the evaluations focused more on measuring academic gains and provide little information about development of insight and motivation, which is the secondary goal of the program. Other concerns included the similarities between the problems in the exercises and testing devices used, so teaching to the test must be questioned. Finally, since the program requires a separate curriculum of long duration, extensive time spent each week, and extensive teacher training, they were also concerned about a "justification of effort" effect on the evaluation efforts (Sternberg & Bhana, 1986, p.63).

Sternberg and Bhana (1986) do report some positive findings from their review. There do appear to be gains attained on standard types of IQ and aptitude measures if the full program is administered by well trained, motivated instructors. Abstract reasoning and spatial visualization are areas that are more likely to show gains than verbal skills. They caution that such gains are not likely to be dramatic, since it is unrealistic to see dramatic gains in such areas over a short time period. They found no evidence of gains in insightful, creative, or synthetic thinking abilities.

They report that transfer to school work is likely "in some cases," but do not elaborate on the issue. They note that transfer does seem to depend on the extent to which teachers successfully "bridge" the principles in the exercises with other experiences requiring the same principles. Similarly, Nickerson et al. (1985) report on Arbitman-Smith, Haywood, and Bransford's 1984 evaluation

which revealed that transfer of ability to solve problems does occur in domain-specific and domain-independent problems, but they do not elaborate on their findings.

Finally, there is the question as to whether the gains noted in individual cases can be adequately assessed by the standardized intelligence tests used in most evaluations (Nickerson et al., 1985). Reports of dramatically changing low-functioning adolescents' options in later life, or the enthusiastic acceptance of using the exercises do not seem to be captured in evaluations as they have been carried out (Chance, 1986).

In another extensive review of reports on empirical research on the IE Program, Savell, Twohig, and Rachford (1986) express similar concerns with interpreting the research reports. They note problems with research design and implementation and the sufficiency of information provided about the study (especially describing the extent to which and how the program was used). These problems contribute to confusion concerning how to interpret research reports. Nevertheless, they identify a subset of studies conducted in Israel, Venezuela, Canada, and the United States that reveal some generalizations and conclusions that seem reasonable. For example, statistically significant group differences were found in populations in these four countries on certain standard nonverbal measures of intelligence. Instruments used measured skill in processing (figural and spatial information), but did not provide clear or consistent information about gains in areas such as self-esteem, impulsivity, classroom behavior, academic achievement, or course content.

Studies that showed these gains had several things in common regarding program implementation: (a) Instructors had at least a week of training, (b) exposure to the program was generally 80 hours or more over a two-year period, and (c) the program was taught in conjunction with some other subject matter that

was interesting and important to the students. Thus, this review makes the important point that the way the program is implemented apparently has a great deal to do with the internal success shown. Moreover, among several suggestions for improvement in studies that would make results more interpretable is the suggestion to focus more specifically on studying the possible effects of the "bridging" exercises, which would reveal more information about transfer.

Productive Thinking Program. Martin Covington's Productive Thinking Program was developed for upper elementary students out of a perceived need to find ways to combat self-defeating achievement patterns in schools. Covington argues that the nature of reward structures in classrooms works against students' motivation to pursue success. In addition to modifying reward systems in classrooms, teachers can teach students component skills (Table 4, Goal A) involved in strategic thinking (Table 4, Goal B) so students can take advantage of newly created opportunities for classroom achievement. He defines strategic thinking as "the capacity to identify and analyze problems and to create and monitor plans for their solution" (Covington, 1985, p.390). Thus, major goals for the program include helping students develop heuristics for generating and developing ideas and for learning to use them in an overall organized approach (Table 4, Goal B). Secondary goals important to the program are that students should value and enjoy thinking activity, and develop the propensity to persist when searching for solutions to problems (Table 4, Goal D) (Nickerson et al., 1985). The program has been used in a wide variety of settings, and of programs designed for use in the 1960s and 1970s, this one has been the most tested (Nickerson et al., 1985).

Table 2 summarizes additional program features. The program consists of 15 booklets centered around developing awareness and use of five kinds of thinking skills: discovering and formulating problems, organizing and using

information, generating ideas, evaluating and improving ideas, and creating new perspectives. Each booklet contains one basic lesson and one problem set, although the materials are not systematic about which type of skill is being taught. Each basic lesson tells a story in cartoon format. The two main characters, Jim and Lila, are children about the ages of the target audience. In each lesson, they solve a mystery with the help of their Uncle John, a high school science teacher.

Students are drawn into actively participating in the mystery-solving process by being asked to generate ideas of their own as the lesson progresses. For example, when Lila and Jim must repeatedly tackle a problem, students are also asked to write their ideas in a Reply Notebook where they state problems in their own words, generate ideas, or examine facts. The teacher gives feedback each step of the way so students can evaluate their progress throughout the problem-solving process. Following each basic lesson, students complete one problem set. These are intended to provide additional practice in the thinking guides included in the lesson. Instead of centering around Jim and Lila's problems, the content of the practice problems involves real problems taken from the social and natural sciences, history, and human relations (Chance, 1986).

The basic lessons and problem sets can be done individually without group discussions, but the program developers recommend more teacher guidance. During each part of the problem-solving process, the teacher is encouraged to give feedback about student performance as well as to encourage students and monitor the students' involvement and interest level. In other words, the teacher's role goes beyond facilitating the thinking process to taking on the additional goal of helping students develop the appropriate attitudes and dispositions to value and use the processes. This requires lively discussion, as in two of the

programs reviewed thus far (e.g., ThinkAbout, SAPA). This kind of teacher involvement (convergent and divergent focus in discussions, close monitoring of students progress, attention to student attitudes and dispositions) contrasts with the narrowly focused involvement called for in CoRT exercises. Like CoRT, SAPA, ThinkAbout and SOI, the Productive Thinking Program provides guidance to teachers through its materials and does not assume further training is necessary. However, it is assumed that teachers have the motivation and desire to study closely the materials and pay attention to appropriate implementation.

Several evaluations have been conducted on the Productive Thinking Program and provide evidence that when test measures are similar to program exercises (problem-solving situations in which subjects are gradually led through the thinking process), performance is enhanced (Nickerson et al., 1985). However, there may be some major difficulties with interpreting some study results because of dependent measures used and the way they were scored (Polson & Jeffries, 1985). For example, the measures include a wide variety of problem-solving experiences that are quite open ended and therefore without a particular solution. In addition, many items were scored for characteristics such as number of ideas generated, but there were no criteria set for determining the quality of ideas nor for how the number of ideas generated influenced reaching a problem solution.

Other studies showed improvements in students' willingness to tackle complex problems, to value their own opinions even if they differed from the group's, and students showed more confidence in their own overall abilities as thinkers (Polson & Jeffries, 1985). On the whole, results show improvements in solving specific types of problems, but do not show evidence of transfer to solving more complex extended problems independently. This may be due to the specific nature of the exercises, which are designed to lead the students step

by step through the thinking process to a specific solution. Such exercises do not provide guidance or practice in solving more complex problems that may not lead to one solution (Nickerson at al., 1985).

An additional problem raised regarding the program materials is that they do not consistently treat particular thinking skills. Instead, there is a great deal of skills overlap across the various exercises, and sometimes students are asked to use skills that have not been formally introduced. While it can be argued that such overlap may be helpful in having students experience the complex nature of the problem solving process, there is the potential problem of not teaching them how to bring together appropriately the specific metacognitive and problem-solving skills. Moreover, the exercises tend to give overall guidelines and advice on using various thinking skills (e.g., think of unusual ideas), but do not elaborate on how to go about doing so, or how to decide when one is using the advice appropriately (Chance, 1986; Polson & Jeffries, 1985).

Programs That Focus on Integrated Application of Goals

Odyssey, Talents Unlimited, and Philosophy for Children use content-related materials to help students learn to develop and apply skills in an integrated fashion. That is, specific attention is given to each of four broad program goals (see Table 4) and students are asked to apply particular skills (Goal A) and strategies (Goal B) taught in contexts that help them understand how and when to use them (Goal C). In addition, there is an emphasis on developing the values and disposition to use the skills in learning and everyday situations (Goal D).

Odyssey

Odyssey (also called Project Intelligence) was developed by an international team of American and Venezuelan psychologists, educators, and

governmental officials (Chance, 1986; Nickerson et al., 1985). It was designed for students of all abilities in fourth through sixth grades, but actual use has been with Venezuelan seventh graders during the 1981-83 school years. Materials are written in English and Spanish. The program's goal is to help students develop the ability to perform a wide variety of intellectual tasks, so it focuses on helping them develop "target abilities" in six areas: foundations of reasoning, understanding language, verbal reasoning, problem solving, decision making, and inventive thinking (Table 4, Goal A). The program materials are "content rich" to maximize the variety of contexts in which the target abilities might be used, which increases the likelihood that the skills will be accessed in new situations (Adams, 1986).

The main goal of the program is to help students develop abilities, but as Chance (1986) points out, program developers also believe that skilled intellectual performance requires learning in three other areas as well (see Table 4, Goals B, C, D): methods (appropriate ways of approaching tasks), knowledge (facts, concepts, principles used in the thinking process), and attitudes (point of view, perspective that enhances performance). Therefore, discussion focuses on helping students learn when and how to apply target skills in addition to providing opportunities to practice them. When new knowledge is needed to complete exercises, it is taught. It is assumed that the content-rich materials will interest and motivate students to help them experience and enjoy the rewards of being curious, showing respect for others' opinions, and enthusiasm for learning (Chance 1986).

Table 2 provides a summary of other program characteristics. The program is divided into six lesson series (according to the six target area abilities listed above). For each of these six categories there is a student book and teacher's manual for a total of 99 individual lessons. Each 45-minute lesson

focuses on a specific set of instructional objectives. The teacher's manual spells out the following for each lesson: lesson format, rationale, objectives, target abilities, materials, classroom procedure. Classroom procedure information includes detailed scripts or imaginary dialogues that illustrate for teachers how they might facilitate the dialogue for the lesson. They are intended to aid teachers in understanding the nature of dialogue that is considered to be an essential part of the program, and such dialogue includes a focus on how and why target abilities apply to a particular situation (Chance, 1986; Nickerson et al., 1985). Formal teacher training is offered by the publisher, but the details in the teacher's manual for each lesson could be adequate for teachers motivated to use their guidance fully (Chance, 1986).

The materials cover a vast range of topics. Some are more general, such as having students figure out the nature of changes they see in a series of drawings (and focusing on which aspects one should look for when considering change). Others pertain to everyday situations such as speculating on authors' intentions in writing a business letter, a personal letter, a newspaper article, or a restaurant ad. Some exercises use materials common to school assignments such as asking students to read a fable and select a moral from among four alternatives (Chance, 1986). This range is purposely provided as a way to maximize the applications of target abilities across a wide range of situations in hopes that transfer is more likely to occur (Adams, 1986).

Two forms of evaluation have taken place with the implementation of the Odyssey Program in Venezuela. One formative evaluation was conducted in 1981-82 to help identify strengths and weaknesses while the program was still being developed. A summative evaluation was conducted in 1982-83 when the program was implemented in barrio schools (students were from families with low socioeconomic status and minimal parent education) (Nickerson et al., 1985). When

comparing a control group with the experimental group, gains were found in both groups in tests of target abilities and standard tests, but gains in the experimental group were larger, especially in target abilities. These preliminary results point to great promise in the program (Chance, 1986; Nickerson et al., 1985; Sternberg & Bhana, 1986), but more needs to be learned about the extent to which such success would occur with other student populations. A special posttest, given to a smaller sample of students, also showed improvements in the extent to which skills taught (e.g., appropriateness of design, clarity of expression, use of supporting reasons) transfer to educational and practical tasks (Resnick, 1987).

Talents Unlimited

Talents Unlimited (TU) is an inservice education model designed to help teachers nurture children's thinking skills, which in turn is expected to improve children's academic performance. It was developed under a Title III Elementary and Secondary Education Act grant in Mobile, Alabama, in 1971. Since that time, its use as an inservice model and implementation in classrooms has spread to over 800 sites across the nation (Hobbs, 1988). Additionally, a growing number of secondary schools are also adapting the model for use in middle and high schools, so developers are working toward a creating comprehensive K-12 model (Hobbs, 1988; Schlichter, Hobbs, & Crump, 1988).

Like SOI, TU is derived from Guilford's structure of the intellect model of intelligence, but Calvin Taylor (1967) argued for a simpler "multiple talent approach" where teachers are helped to identify and nurture students' multiple talents in five talent areas: productive thinking, decision making, planning, forecasting, and communication (Table 4, Goal A). Thus, it is argued that traditional academic talent helps students gain knowledge in academic disciplines while the talent areas (thinking skills clusters) help students process

or use the knowledge to create new solutions to problems (Schlichter, 1986). Because a major goal of the program is to integrate knowledge and talent, teachers are trained to provide systematic opportunities for students to develop skill clusters in all five talent areas and apply them to academic learning as well. Thus, in addition to training teachers to recognize talent areas in children, the program developers produced a series of binders filled with suggested talent activities.

Each activity is structured to include ideas for classroom motivation, suggested teacher directions and discussion, and sample student responses. Moreover, teachers are encouraged to use the talent areas in academic learning situations. For example, in the talent area of productive thinking (to generate multiple, varied, and unusual ideas or solutions and add detail to ideas to improve or make them more interesting), a sample activity for a math unit on surveying and graphing directs students to think of a variety of unusual topics for a survey they will conduct and graph during the day. Teachers are taught that an important aspect of the activities is open discussion with students about what is happening as they work through a problem, to help students develop awareness and understanding of strategies and their use in each talent area (Table 4, Goal B).

In addition, by providing opportunities for students to use the talent processes in each subject area, teachers are to help students develop understanding of ways in which the processes will help them further develop their knowledge and understanding (Table 4, Goal C). Finally, it is expected that students' self-concept and confidence will be increased as they recognize and learn to use the five talent areas, and see that academic talent is but one of many talent areas needed for further learning (Table 4, Goal D).

Table 2 provides a summary of additional program characteristics. TU is an inservice model designed to help teachers develop knowledge, skills and the disposition to nurture the five talent areas in children. Instead of providing paper-and-pencil exercises, program developers provide extensive training for teachers so they are able to play a critical role in mediating students' development in the talent areas. Since the processes for each talent area are used across the various subject areas (as in program exercises in Odyssey), and students are encouraged to discuss and reflect on the use of the processes, this program encourages teachers to teach directly for transfer. Training sessions focus on four areas: (a) teaching classroom teachers about multiple talent theory and talent skills definitions, (b) modeling and demonstration of teaching skills specific to each cluster of thinking skills in the multiple talent model, (c) classroom practice sessions during which teachers receive structured feedback on their performance, and (d) one-to-one and small-group planning sessions in which teachers grapple with ways to implement the program in their particular classroom setting (Schlichter, 1986).

Evaluation efforts have largely focused on the success of the model as an inservice model for teachers, with some focus on evaluation of student performance. Specifically, program developers have focused on examining the extent and nature of program implementation among teachers receiving the training. Extensive analysis of workshop ratings by teachers indicate that the staff development component of the program is effective in enhancing teachers' understandings, skills and attitudes related to implementing the model (Crump, Schlichter & Palk, 1988; Schlichter, 1986). In addition, program developers have examined the impact of the multiple talents model on higher order thinking skills through the use of pre- and posttest measures, including the Torrance Tests of Creative Thinking, the Coopersmith Self-Esteem Inventory, the Stanford

Achievement Test, and the Criterion Reference Tests (a battery of 10 measures developed by project staff and a university research team designed to assess changes in talent areas).

Four experimental and control schools were included in a three-year study. Mixed results from the standardized tests indicate some improvements in some grades during some years. Results from the internally developed criterion-referenced tests indicate success at some grade levels as well (Schlichter, 1981). Thus, there appear to be some gains in experimental groups in overall academic achievement and talent areas over control groups, although results are not conclusive.

Philosophy for Children

The Philosophy for Children Program was developed by Matthew Lipman for children in grades K through 10, with the future goal of developing materials through 12th grade. The broad goal of the program is to help children "discover their intellectual capabilities" (Lipman, 1985). An underlying assumption is that the act of engaging in philosophical inquiry about various issues develops thinking skills. That is, by thinking about thinking, it is assumed that children will learn skills such as making connections, drawing distinctions, defining and classifying, and assessing factual information (Table 4, Goal A). Moreover, repeated practice of these skills in contexts that interest students is intended to facilitate the development, in students, of "cognitive dispositions" showing a readiness to employ the skills they learn (Table 4, Goal D; also see Lipman, 1985). Philosophy for Children is used in over 4000 American elementary and secondary schools, and parts of the program have been translated into French, Chinese, Hebrew, Spanish, German, Portuguese, Danish, and Arabic (Chance, 1986). It is most appropriately used with average and

above-average students, since below-average students may have trouble reading the program novels (unless a novel intended for younger children is used).

Students read novels that were written to be models of inquiry and to illustrate for students basic principles of formal and informal logic. In the six novels, young characters apply philosophical thinking to everyday experiences. Three novels are provided for use in the elementary grades. Pixie is a novel for children in grades through four and involves reasoning about language. Kio and Gus is also intended for use with grades kindergarten through four and centers around reasoning about nature. Harry Stottlemeier's Discovery, the first to be written, is used in grades four through seven and focuses on developing basic reasoning skills. The other three novels, intended for use in grades 7 through 12, include reasoning about ethics, reasoning in language arts, and reasoning in social studies. Thus, the focus in the early grades is on more general reasoning skills and experiences. As the children in the program get older, the ties to subject matter become more explicit.

Table 2 summarizes additional features of the program. Exercises accompanying the novels afford students the opportunity to practice and assess particular thinking skills such as syllogistic reasoning, formal analogy problems, informal reasoning, and creativity and verbal fluency. The objects of thought in the discussions of the novels are philosophical issues. During the exercises, the focus is on the reasoning skills to be developed. These activities are intended to take place within a "community of inquiry," where students and teachers engage in dialogue focused on evaluating the content and quality of the dialogue (Bransford et al., 1985).

Instead of focusing on teaching the skills separately through the exercises provided in the program, Lipman (1985) argues for the need to help students coordinate thinking skills, which requires modeling from the teacher

during philosophical discussions, as well as encouraging dispositions to employ the skills in a coordinated fashion (Table 4, Goals B, C, D). As with other programs with multiple goals, the teacher's role is to encourage and support students as they reflect on their discussions and to help them become aware of their thinking processes through the discussions of the novels and participation in exercises. The hope is to facilitate and reinforce an interest in philosophical questions that will last beyond the duration of the course so that students will show improvement in their ability to think and in what they think about (Nickerson et al., 1985). The program is intended to be used for three 40-minute periods per week, which is a substantial time investment in an elementary or secondary curriculum.

Philosophy for Children requires extensive teacher training. Lipman (1985) maintains that guiding philosophical inquiry is a skill to be learned, and it is best learned in the same fashion children do. Therefore, he recommends that teachers participate in reading, exercises, and discussions during a two-week summer workshop with experienced trainers. One-year training is also available where trainers visit the teacher's school weekly to provide training and supervise the teacher's implementation of the program. Unlike SOI, Odyssey, ThinkAbout, and SAPA, the developers assume teachers need more than commitment to teach thinking skills and more guidance than use of teachers' manuals. Like IE and TU, this program requires considerable time investment in learning to use the program properly, and considerable skill in implementing it.

Sternberg and Bhana (1986) report there is little evidence available about use of any of the novels except Harry Stottlemeir's Discovery with children in grades four through seven. Instead of focusing the evaluations on component parts of the program, it has been evaluated as a whole. Therefore, little information is provided on subject drop-out, class selection, durability,

transfer, subject population, experimenter bias, and statistical analysis. They also raise the issue of interpretive problems since most evaluation studies are reported in Lipman's own journal, Thinking. Evaluation data show that different groups of students appear to make gains in different areas, but there is no explanation as to why (Bransford et al., 1985). The greatest gains seem to be in verbal tests of critical thinking abilities, which makes sense in light of the heavy use of reading and discussion (Sternberg & Bhana, 1986).

Nevertheless, despite the lack of specific experimental evidence to support the program's effectiveness, there do seem to be some promising aspects. Transfer is more likely because of the use of everyday situations in the novels and because of repeated opportunities to reinforce earlier learnings across the grades. Informal comments on the program reveal a positive attitude toward it from teachers and students. Reports of enthusiastic discussions where students actively participate in philosophical inquiry and carefully listen to one another is important evidence for the likelihood of developing long lasting interests in philosophical inquiry. However, there is no information available regarding the general question of the cost of using the program (e.g., time invested, training requirements, problems of continued use across the grade levels) compared to the benefits realized.

Programs That Use Language and Symbol Manipulation

Reciprocal Teaching, the Expository Writing Program, and LOGO were not initially designed to teach thinking skills. Instead, they were designed to focus on improving knowledge, understanding, and use of three skill areas: reading comprehension, written composition, and computer programming. They are included in this review because program developers claim that developing these skills is not just an end in itself but also enables students to explore and understand subject matter concepts and related skills. It is assumed that

reading, writing, and programming are occasions for students to learn more about the content areas typically studied in school, ways to solve problems, and to develop a better understanding of and skill in using occasions to learn. This, in turn, will improve one's thinking about subject matter content. The methods used in each program include highly specific teacher support for learning, where a mediated learning environment is seen as key to the program's success. Materials in each program are specifically related to the skill areas under development.

Reciprocal Teaching

Reciprocal teaching started as a set of procedures designed to help upper elementary students develop reading comprehension skills. Its originators, Annmarie Palincsar and Ann Brown, wanted to develop a way for students to develop and practice the deliberate use of understanding processes when they read text material (see Table 4, Goals A, B, & C; also, see Reeve, Palincsar, & Brown 1987). An underlying assumption of the instructional procedure is that if students learn to use comprehension strategies deliberately and become aware of ways to control their use strategically, they will learn to think critically about material they read in academic subjects.

Instead of skirting the issue of prior knowledge in thinking, this program rests on the assumption that the ability to comprehend new information is an important part of thinking and problem solving. The overall goal of using this instructional procedure is to help students learn to use and value "deliberate effortful cognition" to address problems requiring academic thinking skills (Table 4, Goals B & D; also, see Reeve et al., 1987). A secondary goal for the program is to help students develop knowledge about thinking so that they understand how the methods they are learning in reading comprehension influence

the thinking process (Table 4, Goal C). Reciprocal teaching began as a series of training studies, and since then its use in classrooms has increased.

The program centers around teaching students to use four key strategies as they read regular text materials in the classroom: summarizing, questioning, clarifying, and predicting. These strategies are considered key because they can be used to foster comprehension skills and comprehension monitoring activity (Reeve at al., 1987). Instead of just learning to do a thinking activity, students are also taught to assess the quality of their activity.

Table 2 includes a summary of additional program characteristics. The role of the teacher in fostering understanding and use of the four key strategies is critical. The main teaching activity centers around carefully constructed dialogue about text passages. Teachers must first ascertain where instruction should begin. This might entail beginning with discussions that center around what a summarizing or questioning activity is, and how it is used. Time is also spent providing a rationale for learning the comprehension strategies so that students are motivated to learn the strategies and see how they apply to learning in the subject areas. This is followed by careful modeling of appropriate use of the strategy by the teacher, including sharing her thought processes about the strategy use.

As students begin using the strategies, the teacher diagnoses difficulties on the spot, gives feedback to students, and gradually expects them to demonstrate more competence in strategy use. Gradually, the teacher asks the students to take on the role of "teacher" and begin using the strategies with the class or a group, thinking aloud about the process, receiving feedback from teacher and students, and gradually increasing competence in strategy use. The nature of this process is gradual because of the underlying assumption that teaching this process requires anticipation of students' competence, so that

they are continually at the edge of their learning capacity. Such knowledge requires the teacher to carefully monitor the students' level of competence and continually adjust the amount and type of support provided (Reeve at al., 1987).

Taking on this role requires extensive training for teachers in several areas. First, teachers must understand the appropriate use of the four strategies (summarizing, questioning, clarifying, and predicting), and how they apply to increased understanding of a particular passage (and ultimately to the content being studied). Without a thorough understanding of the text material, teachers could miss opportunities to show students the value of such activities as clarifying and predicting, and such activities could be reduced to trivial exercises.

Second, teachers need to learn to model the use of the strategies. It is one thing to be a good reader and another to tell others how one goes about comprehending the material (Pearson & Dole, 1987). Third, teachers need to learn how to "scaffold" (Palincsar & Brown, 1985) so that the teaching process becomes one of gradually relinquishing to the student responsibility for using the process. Students need the opportunity to practice the strategies with support, but that support must eventually be removed at the appropriate time so students can learn to apply them independently. In addition, this gives teachers the opportunity to see how well students can use the strategies and know when remediation is necessary.

Palincsar and Brown have provided training for teachers in the above areas, but the extent to which they address the issue of how the four strategies specifically or uniquely apply to different subject areas is unclear. They do give sample dialogues that apply to specific text material (Palincsar, in press; Palincsar & Brown, 1985), but it is not apparent that the nature of the

content is directly related to the nature of the strategies. For example, what does "questioning" or "clarifying" look like in science and social studies? Are the activities different for each? What is the nature of the issues that arise in each area? Issues such as these might be more specifically explored and dealt with directly in teacher training, especially since Reeve, Palincsar, and Brown (1987) advocate use of these strategies in other subject areas.

Use of Reciprocal Teaching has been extensively evaluated, and these efforts provide inspiration that thorough evaluation of complex educational interventions is possible (Pressley et al., 1985). Pearson and Dole (1987) summarize outcomes of several sets of studies. One set of studies evaluated the use of the reciprocal teaching procedure to measure poor readers' daily independent comprehension test scores immediately after the intervention, eight weeks later, and six months later. In all instances scores increased from 40% to 75% correct. When standardized measures of comprehension, social studies, and science were compared to a control group's measures in these areas, those participant's gains were consistently greater. In addition, a series of transfer tests showed reliable improvement in reading and writing. The use of the procedures was also compared across different types of teachers (master teachers, average teachers, and peer tutors), and all three groups achieved success. In a series of comparative studies, reciprocal teaching showed significant gains over practice-alone treatment or isolated skills treatment. Finally, teaching methods were compared and it was found that the reciprocal teaching method was superior to teaching where students did not gradually assume responsibility for their own learning, and where students assumed responsibility according to a predetermined schedule.

These findings indicate a high degree of success (including stability of treatment over time and transfer to reading and writing activities), but also

indicate that the program's success is due to using its methods correctly as well as focusing on the key strategies. Apparently the method (carefully constructed dialogue and appropriate scaffolding) is just as important as the program content. In this program, the role of teacher as mediator is as key as it is in IE, Odyssey, TU, and Philosophy for Children.

Expository Writing Program

The Expository Writing Program was developed for use with upper elementary and early middle school students, and grew out of a three-year study designed to improve students' comprehension and composition of expository text (Kirschner, Raphael, & Englert, 1986; Raphael, Englert & Kirschner, 1986; Raphael & Kirschner, 1985; Raphael, Kirschner & Englert, 1986a, 1986b). The "program" consists of a manual for teachers who wish to implement a process approach to writing as it was designed and implemented in the three-year Teaching Expository Reading and Writing Project. Like Reciprocal Teaching, it started with a focus on developing school related skills (in this case, reading and writing). Because of its emphasis on teaching students strategies that involve problem-solving and delineating emergent problems through reading and writing, it is included in this review of programs that teach thinking skills.

Assumptions that underlie the program come from research in three areas: question-answer relationships, expository text structures, and the writing process. The goals of the EWP are to help students (a) integrate information from across texts; (b) learn about and use appropriate text structures to comprehend written material and create their own written text; and (c) learn about and use the writing process to find information, plan, edit, and revise different types of texts (Table 4, Goals A, B, C).

Thus, the developers see writing expository text as two distinct, but interrelated problems. One problem is to help students understand underlying

structure of text material so they can better comprehend it (and eventually write about it). In this way, their goal is similar to that of Reciprocal Teaching, where students are taught ways to better comprehend text material (Table 4, Goal A). These two programs also share a focus on helping students become aware of their own learning process so they can use it to monitor their own learning and become independent readers and writers (Goal B).

A second problem goes beyond the goals of Reciprocal Teaching to help students learn to manage writing about subject matter content as well. This program focuses on teaching students to understand the underlying structure of social studies texts and to use different text structures in their own writing (Goal C). In addition, research on the writing process influenced the developers to focus on showing teachers how to develop an appropriate environment for writers so that the non-linear writing process (find information, plan, edit, revise) would be used as a tool for their thinking and writing, and not as a set of assignments to fulfill (Raphael & Kirschner, 1985).

Additional features of the program are summarized in Table 2. The manual (Raphael, Kirschner, & Englert, 1986b) consists of a rationale for the program, a set of directions for teachers to follow, and sample materials to use with students to teach them about text structures and to teach them to use the planning, editing, and revising stages of writing different types of text (e.g., comparison/contrast, problem/cause, problem/solution, explanation, story).

Like Reciprocal Teaching, this program emphasizes the importance of the teacher's role in the learning process. Teachers are encouraged to conduct discussions carefully that make explicit their own and their students' thinking processes as they read text and plan their writing. Thinking about comprehension and writing tasks is explicitly modelled by the teacher, not described or assumed. Like Reciprocal Teaching, it is also assumed that teachers will

continually monitor students' current level of understanding and skill and attempt to provide appropriate scaffolding along the way. Peer-editing groups guided by the teacher are also a means by which students practice skills and become more aware of thinking processes during the writing process. The program developers claim that the strength of the program lies in the interconnections made between the reading and writing process, where students are shown how to bring both processes together to comprehend and write about social studies content.

During the three-year study, researchers worked collaboratively with classroom teachers to develop program materials. It appears that the manual (Raphael et al., 1986b) is intended as a sufficient resource for teachers to use on their own if they wish to implement EWP in their classrooms, since there is no discussion in the manual of further training needed. While the manual clearly states what the teacher should do to implement the plan, it is uncertain that any teacher automatically has the knowledge or skill needed to provide such closely guided instruction.

Formal study of the program has focused on changes in teachers' knowledge and implementation of the writing program (Kirschner et al., 1986) and their knowledge of the writing process (Raphael et al., 1986a). It was found that after participation in the EWP, teachers viewed writing as a process where genuine purpose and audience are essential, and saw writing as a form of communication instead of a place to assess skills. Information about student performance is limited to examples showing improved ability to organize text and convey information, improved ability to write narratives, and improved attitudes toward writing. No studies have been conducted to assess how students might transfer what they learn about text structure and writing in the social studies to writing about other content areas, writing about social studies content in

other contexts, or their general ability to analyze text material for its underlying structure.

LOGO

LOGO is a computer language suited for use by children throughout the elementary years. Its use has been popularized by Seymour Papert (1980). Because it requires the availability of microcomputers in classrooms, its use has as yet been limited; however, computer use in classrooms is increasing all the time (Nickerson et al., 1985). Programming in the LOGO language provides children the opportunity to explore mathematical and logical concepts. The computer is used as a tool to learn about areas such as: problem-solving strategies, fractions, algebra, word problems, trigonometry, and geometry.

In addition to helping students learn mathematical content, program developers claim that students will also develop problem-solving skills through programming in LOGO (Table 4, Goal A). Thus, it shares with Reciprocal Teaching and EWP the goal of promoting generalized skills (e.g., problem-solving) through developing and using another skill, in this case, programming. This review focuses on the claim that use of LOGO improves general problem solving abilities and looks at recent changes in program goals and learning environments in which LOGO is used that might improve the likelihood of transfer of problem solving strategies to other domains.

Papert's initial recommendations for using LOGO with children minimized the role of the teacher. He claimed that teachers need to learn the LOGO language so they can teach it to students, but he recommended letting students explore and discover uses on their own. However, a study that investigated the extent to which students transfer planning skills from the activity of programming to other experimental tasks that also require planning (but did not

involve computers) found no effects (Pea & Kurland, 1984). Instead, the children "played" with LOGO, but ignored the conceptually challenging aspects of LOGO to which Papert claimed they would gravitate. The teachers involved in the study concluded that they had to plan more specifically what they intended for students to get out of using the language, and they needed to provide appropriate support for helping them realize those goals (Newman, 1985). Unlike Reciprocal Teaching and EWP, these LOGO users left out the careful teacher goal-setting, modeling, and support that is needed to help students develop an awareness and appreciation of the value of processes such as planning in improving thinking. Thus, in the way LOGO was originally implemented in classrooms, it focused on the single goal of developing problem-solving skills, and used a non-directive approach to instruction.

More recent attempts to use LOGO to develop generalized problem-solving skills are moving in a different direction. For example, Black and his colleagues (Black et al., 1988) describe efforts to re-think and reorganize the pedagogy surrounding LOGO use. These researchers reviewed several studies on the effectiveness in using LOGO as a tool to teach problem solving (Swan & Black, undated) and studied their own use of LOGO with a group of children in the fourth through eighth grades. They argue that positive effects resulted from LOGO use that used a particular kind of pedagogy: (a) teachers and students focused on specific aspects of the general problem-solving process (e.g., subgoals formation, forward chaining, backward chaining, systematic trial and error, alternative problem representation, analogical reasoning); (b) teachers provided direct instruction in the identified component skills; and (c) a high degree of teacher mediation was required in the learning environment. Other researchers (e.g., Emihovich & Miller, 1988; Lehrer, 1986) also encourage taking a close look at the environment in which LOGO is used and the nature of the

social as well as cognitive development that takes place over time to understand why and how the use of LOGO helps students generalize the skills they are developing to further learning situations.

These recent changes in the pedagogy surrounding the use of LOGO (identification of specific component skills that are directly taught [Table 4, Goal A], a high degree of teacher mediation, more attention to ways in which teachers must scaffold students' learning across experiences [Goal B]) show a movement toward creating features of a learning environment that encourage transfer (see Table 2). Indeed, results from pre- and posttests given to a group of fourth through eighth graders (Black, Swan, & Schwartz., 1988; Swan & Black, undated) indicate improvement in strategies, and transfer of these strategies to noncomputing domains. More studies of this nature are required to learn more about the potential for transfer of problem solving strategies learned in a LOGO-based problem-solving program to noncomputing situations.

Summary

The eight programs reviewed in this section share a focus on multiple goals designed to improve thinking. Each program claims some success at fostering better thinking, but only three (Reciprocal Teaching, Odyssey, and LOGO) provide specific evidence of transfer of such abilities to other domains (Table 2). However, like the first group of programs reviewed, these programs do reveal some qualities that are important to consider in working toward improving thinking skills. Table 2 serves as a useful summary of program characteristics to be highlighted in the discussion that follows.

Multiple Goals Are Needed

What qualities in programs enhance the likelihood of transfer? This is a question of how to get students to transfer use of skills and strategies (Table

2, Goals A & B) they have learned in one situation to having the conditional knowledge (Goal C), awareness and disposition (Goal D) to use it in others. In other words, it is a question of whether students have access to the intellectual skills they have developed (Prawat, 1988). Of the eight programs reviewed in this section, four take on and give specific attention to all four goals: Odyssey, TU, Philosophy for Children, and Reciprocal Teaching. Reciprocal Teaching provides specific evidence of transfer of skills to other domains.

Test results on a small student sample of seventh-grade students using Odyssey show improvements in qualitative aspects of thinking (e.g., appropriateness of design, clarity of expression, and use of supporting reasons), so some evidence of students being able to use the skills in educationally and practically relevant tasks is provided. Study of overall achievement did not show a pattern of improvement as a result of TU teaching, yet teachers report much student enthusiam and widespread use of the talent areas in their classrooms (Barbieri, 1988; Schlichter, Hobbs, & Crump, 1988). While there is no specific evidence from formal studies of transfer of skills taught in Philosophy for Children to other situations, there are abundant informal reports that enthusiastic discussions, positive attitudes toward philosophical discussions, the use of everyday situations as focal points for applying philosophical thinking, and repeated opportunities to develop and improve skills across the grades all point toward the likelihood of transfer.

Two programs, IE and the Productive Thinking Program, take on three of the four goals, so that they attempt to help students learn skills, learn strategies for using them, and also attempt to develop positive attitudes and dispositions to use the skills. Like Odyssey, TU, Philosophy for Children, and Reciprocal Teaching, these two programs intend to help students experience and learn to enjoy the thrill of discovery, and the satisfaction gained in pursuing

one's thinking. If students develop an awareness of their own thinking strategies (Table 2, Goal B) and a positive attitude toward the work it takes to think more clearly (Table 2, Goal D), it is more likely they will be motivated to use the skills in other situations. Evaluation efforts show internal success in both programs, so that students do show gains in target skills when similar test items are used. More study of each program is needed to document whether transfer does occur when students are not also taught more specifically when to use particular knowledge and skills (Table 2, Goal C).

EWP works toward three of the four goals (Table 2, Goals A, B, C), leaving development of attitudes and dispositions (Goal D) as a potential outcome that is not directly addressed. Since little study of student outcomes has taken place, it is difficult to address the issue of transfer of the use of skills developed to other domains. Further study is needed.

Finally, people using LOGO are changing and adding goals as they learn more about its potential success. Current use focuses on developing two goals (Table 2, Goals A & B) and the added focus on developing strategic knowledge and skill seems to make a difference in its success. Students need help in becoming aware of the generalizability of the strategies they are using. More studies need to be done to determine whether focusing on two of the four goals is adequate for successful transfer of problem-solving strategies to noncomputer domains.

Thus, specific instruction and support in working toward multiple program goals point toward increasing the likelihood of transfer. Working toward Goal A is essential; skills must be taught. However, <u>access</u> to such skills is also essential if students are to be able to use them in further learning situations (Prawat, 1988). Therefore, also working toward Goals B, C, and D will more likely ensure that students will use cognitive processes widely and frequently (Resnick, 1987).

Teaching Methods and Materials

Six of the eight programs use content-related materials (Odyssey, TU, Philosophy for Children, Reciprocal Teaching, EWP, LOGO), while two use general materials that take the focus off subject matter content (IE, Productive Thinking Program, [see Table 2]). Odyssey purposely uses "content-rich" materials to increase the likelihood of transfer. TU inservice training encourages teachers to find and use opportunities to develop talent areas in all subject area learning. Philosophy for Children uses a particular genre of children's literature to promote and provide a context for philosophical inquiry (Lipman, 1987). Reciprocal Teaching and EWP use school subjects and materials as the focus of their instruction. LOGO uses a programming language that embodies a specific type of problem solving that draws on conceptual schemes related to computers--algorithmic thinking, procedural thinking, logical debugging, modularization (Nix, 1988). In these cases, the connections the program experiences have with content seem to challenge students and promote interest. Moreover, it is assumed that the subject matter will provide stimulation to think critically.

Although the Productive Thinking Program limits its exercises to everyday situations, it uses a comic format and everyday characters and situations intended to interest students and hold their attention. IE developers report that students find the generic exercises "intrinsically interesting" as one would find a puzzle fascinating to solve. However, since the focus in this program and in the others is on the lively interaction between and among teachers and students (in contrast to programs like SOI and CoRT where interactions are rather routine), there seems to be a complex interaction between the kinds of materials used, the nature of interaction surrounding the materials, and the likelihood of transfer. Also, it should be noted that those studies that

reported the greatest internal success in implementation of IE were ones where IE was taught in conjunction with other subject matter of interest and importance to the students (Savell et al., 1986). Thus, while content-related materials seem to be more interesting to students, mere interest is not enough.

All programs reviewed in this section call for a high degree of teacher mediation. It seems that a particular kind of learning environment is required if skills and strategies students learn will be valued and used in further learning situations. Moreover, without specific focus on how and when to use the skills (Table 2, Goal C), there may be less likelihood that students will know how and when to use the skills in other situations. Lively dialogue, collaborative exploration of content and strategies, and careful scaffolding (of skill development, strategy awareness and use, development of conditional knowledge, and development of the disposition to use the skills) increase the likelihood of success in promoting transfer of skills to further learning situations.

Teacher Training

Five of the eight programs (IE, Odyssey, TU, Philosophy for Children, Reciprocal Teaching) provide and advocate extensive teacher training (Table 2). For example, studies reporting internal success for IE implementation note that instructors using the program had at least a week of training (Savell et al., 1986). The Productive Thinking Program and EWP assume careful and motivated use of the materials is adequate (although EWP did begin with careful work with teachers initially). Current LOGO users seem to be heading in the direction of helping teachers think more clearly and concisely about the nature of the environment in which problem solving is successfully learned and generalized. When programs with multiple goals are offered, it does seem that teacher training should be offered. For example, as Reciprocal Teaching is described in the literature (Palincsar, in press; Palincsar & Brown, 1985; Reeve at al., 1987), it

is an extremely complex activity. It requires rich knowledge of the key strategies being taught, techniques for determining student progress, ways to structure dialogues to provide appropriate support, and content in the written text. It seems unrealistic to assume that any program that promotes thinking can simply be carried out as a "how to" by any teacher.

The Persistent Question of Transfer

There is little definitive evaluation evidence that programs promoting general thinking skills are effective in helping students think better in general, and yet the available evidence points toward characteristics of some of the programs that seem promising. In this final section, a summary of important program characteristics is provided. This is followed by a discussion of issues and difficulties in evaluating the success of thinking skills programs.

Program Development

The overall goals of the programs shape their content and methods, so program goals are an extremely important element in the development of any effort to teach students higher order thinking skills. In general, the programs reviewed focus on teaching students to use analytic and reasoning skills in problem-solving situations in academic and everyday contexts and try to communicate general principles by which students will learn to apply their skills. Some programs use subject matter-oriented materials as well, but their focus is still on developing skills and strategies more than on developing understanding of content. The first group of programs reviewed center their efforts on the single goal of developing particular thinking skills, and the second group of programs focus on helping students work toward multiple goals (see Table 1).

This review has shown that students can benefit, at least in immediate gains in specific contexts, from purposeful teaching and practice of specific

skills (Table 1, Goal A). In addition, three other outcomes (developing metacognitive awareness and strategies [Goal B], developing conditional knowledge [Goal C], developing appropriate attitudes and dispositions [Goal D]) are also important for several of the programs. Nickerson et al. (1985) argue that all four outcomes are necessary for successful teaching of thinking. Why are all four necessary?

Successfully teaching of thinking involves getting students to transfer or habitually use abilities or skills in situations beyond program exercises. The overarching goal is to do more than teach higher order thinking during program exercises; higher order thinking should take place in everyday and learning experiences. Most of the programs claim transfer will occur by participation in the program, but are unable to provide evidence to support that claim. What seems to be lacking in many of these programs are direct efforts at promoting transfer in program materials and methods; without such efforts, transfer does not just happen. Thus, instead of placing transfer as an implicit or understood outcome of the program, perhaps it should be an explicit outcome that holds equal importance with the other four outcomes for programs. Programs that explicitly teach for transfer (see Table 2) do show promise.

If transfer is an important outcome for a program designed to teach higher order thinking, what are important ingredients for program developers to keep in mind? Polson and Jeffries (1985) offer four criteria for analyzing whether programs are consistent with current research on problem solving: developing explicit cognitive objectives that reflect an explicit model of thinking and problem solving; using a wide variety of explicit problem-solving techniques; developing a control schema or management strategies; and providing useful examples and problems of graded difficulty that provide drill and practice. When these four criteria are followed, it seems that programs can succeed at showing

immediate gains in using program exercises or other similar materials (e.g., CoRT, Productive Thinking Program), but they do not necessarily show transfer gains.

Sternberg (1987) offers some additional guidelines intended to increase the likelihood of transfer in a thinking skills program. These guidelines are consistent with program characteristics described in this review regarding transfer (see Table 2). First, he recommends specific training for developing executive skills (Table 2, Goal B). Students need to be taught to be aware of and manage their use of the target skills (e.g., Reciprocal Teaching, Philosophy for Children, TU). Second, general principles or rules for thinking must be taught in the context of a variety of disciplines (Table 2: Materials). This allows students to understand how the principles cut across subject matter areas. Odyssey, ThinkAbout, TU, and Reciprocal Teaching provide materials and experiences across disciplines, but only Reciprocal Teaching explicitly directs teachers to discuss how and when the skills can be used in various subject matter domains. Also, the question was raised earlier as to whether Reciprocal Teaching considers differences in how the key strategies apply to various subject areas (e.g., Is summarizing, questioning, clarifying, or predicting different for science and math, and if so, how?). Thus it is also important to raise the issue of the limitations of the generalities being taught and to examine closely when particular thinking skills might best be taught in specific subject matter contexts (Alexander & Judy, in press; Resnick, 1987).

A third recommendation Sternberg (1987) offers is that principles should be presented in contexts that range from the abstract (without regard to particular content) to concrete (particular instances; see Table 2, Goals B & C). Philosophy for Children's emphasis on the value of "thinking about thinking" in

addition to its emphasis on applying logic to specific situations is a good example of this blend of experiences. Fourth, Sternberg recommends that contexts in which principles and rules are presented should vary from the academic to the practical so students can see instances of how principles that apply to their academic learning also apply to everyday situations (Table 2, Goal C). Odyssey, TU, and ThinkAbout probably come the closest to providing a mixture of both kinds of contexts. However, they do not explicitly show students what the relationship is between applying principles in both instances, and the mere presence of both kinds does not guarantee that students will see and make the connections on their own. TU seems to rely on teachers' knowledge and understanding of such connections in order to make them explicit to students.

Fifth, Sternberg (1987) argues for using multiple media of instruction (e.g., lecture, discussion, reading, writing, individual and group projects) to ensure the likelihood that students will internalize what is taught in the program (Table 2: Intended Teacher Mediation, and Materials). This recommendation seems to reflect good pedagogy for helping students understand principles and practice skills and enjoy the learning process; however, without explicit attention to how they are reflected in various experiences (see Table 2, Transfer of Skills), there is not necessarily more likelihood that internalization will occur.

Finally, Sternberg argues that while individualization is difficult to achieve, some measure of it is necessary to account for individual differences. Some programs, such as SOI, are extremely individualized with individual prescriptions for students based on a diagnostic test. However, SOI evaluation results do not show evidence of transfer to nontest-like materials. Reciprocal Teaching is also diagnostic and somewhat individualized, but in a more flexible way, where the diagnosis occurs throughout instruction and

further instruction is delicately adjusted according to the teacher's perception of what students need. Careful scaffolding proves more successful in leading to transfer than individualization that is done in a pre- and posttest fashion (Table 2: Intended Degree of Teacher Mediation, Teacher Training).

If transfer is taken seriously as an important and explicit outcome of efforts to teach higher order thinking, the above recommendations should be taken as a set, rather than selectively implemented (Table 2, Goals A, B, C, D). Transfer requires explicit focus of instruction on metacognitive awareness and strategies in addition to teaching specific abilities or skills. In addition, it requires showing students how and why principles and skills apply in a variety of contexts (various academic subject areas; academic and practical; abstract and concrete). These insights do not happen on their own. Finally, it requires good pedagogy (use of multiple media, and suited to individuals as well as to the group) and appropriate scaffolding. In the following section, recommendations are given for specific methods and activities that will promote important outcomes for teaching higher order thinking.

Implementation

The importance of the role of the teacher has come up repeatedly in this review. Those programs calling for explicit discussion of target abilities and skills and that place the teacher in a supportive role for monitoring and developing abilities, and skills (e.g, IE, Odyssey, TU, Philosophy for Children, Reciprocal Teaching, EWP) and developing awareness of control strategies and their use (e.g., Reciprocal Teaching, Philosophy for Children, TU, EWP), seem to show the most promise. Moreover, the better teachers are prepared to use the program (e.g., IE, Odyssey, TU, Philosophy for Children, Reciprocal Teaching), the better they will be able to manage the complexities involved in achieving transfer as well as other important program goals. Teachers must be

knowledgeable of specific cognitive objectives and understand how program exercises provide instances for practice of particular target abilities and skills. They need to know how to foster awareness and use of strategies that help students strategically apply their knowledge and skill. Finally, they need thorough understanding of subject matter domains to which they will help students see the abilities and skills apply. This set of abilities requires training beyond what typical elementary classroom teachers have (Table 2: Teacher Training).

An issue related to teacher training is the extent to which teachers need a separate program to teach thinking skills. Since transfer is more likely to occur when instruction, practice, and reinforcement occur in a variety of subject areas, why not simply teach the skills as they teach the subject areas? Program developers argue that having a separate program ensures that time will be spent focusing on thinking skills. However, that is only true if the program is implemented as planned (in method and duration), if sufficient time and resources are allowed, and if it fits with other priorities in the school. They also argue that specific programs help make students more aware that they are learning to think and focus more systematically and specifically on developing target skills.

Reciprocal Teaching, EWP, and TU are good examples of infusing the teaching of thinking into regular school work in a systematic way. For instance, in Reciprocal Teaching, time and effort are spent focusing on developing key strategies to improve reading comprehension, while text material is used to practice the developing skill. Similarly, the EWP focuses on social studies text material while teaching students to better comprehend and write about the material. Such infusion helps students see direct application of the skills to helping them learn, instead of having them think that learning to think is an

isolated activity. Moreover, using elements of thinking in an integrated way provides greater assurance that students' abilities to learn, think, and reason are being promoted (Resnick, 1987).

The guidelines for increasing the likelihood of transfer discussed throughout this review (Table 2) point toward the merits of using various programs as an aid in teaching thinking, but also infusing the application of such programs to subject matter areas (Sternberg, 1987). Developing higher order thinking skills and learning when and how to use them is a long-term goal that must be worked toward throughout the elementary (and secondary) years of schooling. The infusion of teaching for specific abilities, skills, knowledge of thinking, and appropriate attitudes and dispositions into subject matter domains (through using programs and through asking students to think critically about subject matter) is the most likely way to achieve long term effects and to show students how particular skills and abilities apply to different learning experiences (Alexander & Judy, in press). In both instances, more time devoted in the teaching day to such outcomes is required.

Such infusion of specific programs into regular teaching routines is becoming more common and widespread (see Brandt 1988). Many of the newer practices in using programs designed to develop thinking skills stem from problems identified with isolated skill instruction, and from logistical problems of finding time in the school curriculum to add yet another skill area that takes time in the school day. Current trends are moving in the direction of using programs like TU to organize thinking skill instruction in a systematic way, but to make sure students also have the opportunity to regularly apply the skills in meaningful ways to learning of subject matter content and to everyday reasoning.

Evaluation Issues

A theme throughout this review has been the lack of specific evidence that programs promote desired outcomes or that the effects are long term. One reason for these problems is that evaluation efforts and analysis of program materials and methods have focused on different evaluation questions, which makes it difficult to compare programs. Reviewers of the programs tend to focus on analyzing several aspects of the program (e.g., underlying assumptions; program materials, methods, target audiences, implementation patterns and problems, and teacher qualifications) in addition to paying attention to program effects (e.g., Bransford et al., 1985; Chance, 1986; Nickerson et al., 1985; Polson & Jeffries, 1985; Savell, Twohig, & Rachford, 1986; Sternberg & Bhana, 1986). They conclude that despite the lack of clear evidence, many of the programs show promise, seem to do some good, and are at least able to provide anecdotal evidence that students are learning from the program. Much of this optimism in the face of little evidence stems from these reviewers' knowledge and understanding of evaluation problems.

There are many obstacles to evaluation that program developers or school districts must face (Bransford, Burns, Delclos, & Vye, 1986; Nickerson et al., 1985; Polson & Jeffries, 1985; Sternberg & Bhana, 1986). First, summative evaluation data are difficult to collect. Evaluators must contend with control issues (e.g., defining appropriate control group treatments; controlling for the quality of teaching; controlling for consistency in program implementation). In addition, information regarding generalized and long-term effects requires collecting data in situations that are different from the context in which the program was taught and requires collection points across a substantial amount of time. These requirements are difficult to meet and may be impossible for evaluators to control. In addition, a major problem with some

program evaluations has been that programs try to assess transfer of skills without first determining whether students learned the target skills.

A second major problem is identifying adequate measures for determining whether thinking ability has improved. There is no taxonomy of problem-solving and comprehension techniques or of metacognitive skills. Therefore, numerous measures have been used to evaluate program effects, and there are great differences in opinion as to which ones are adequate. Since so many different measures have been used, cross-program comparisons are difficult or impossible to make. Also, there are problems with whether outcome measures overlap program content, so that programs are accused of "teaching to the test," and transfer of learning cannot be assessed. Moreover, standard tests may not measure certain aspects of desired outcomes. For example, judging the merits of a plausible argument is an important skill, but difficult to measure with available instruments. An additional complication comes from comparing pre- and posttest measures for statistically significant gains. Such gains do not provide guidelines for deciding whether the effects are sufficient to justify the cost (in time and resources) for implementing the program. Finally, standard measures do not address unintended positive effects (e.g., improved attitudes, improved quality of classroom discussions) or negative effects (e.g., not fully meeting goals is discouraging and unmotivating to teachers and students). Other ways must be devised to measure these kinds of effects.

These are examples of obstacles to evaluations of program effectiveness that explain the lack of evidence to support program claims. However, that does not mean evaluations should not be done. One kind of evaluation that has not yet been discussed is formative or ongoing evaluation of both the program's effectiveness and of group and individual progress throughout instruction. These are also important sources of information for evaluating success and

providing ideas for program improvement. The second kind, summative evaluation, must be carried out more extensively and carefully if we are to understand better the long-term effects of such efforts. Program developers and school districts need to make use of available guidelines for conducting fruitful evaluations (e.g., Baron, 1987; Nickerson et al., 1985) and more carefully document the successes that have occurred. The evaluations that have been conducted on Reciprocal Teaching (e.g., Brown & Palincsar, 1985) and Odyssey (e.g., Herrnstein, Nickerson, Sanchez, & Swets, 1986) are useful examples of rigorous efforts to study several aspects of a program, and provide inspiration that such evaluations can and should take place.

Concluding Remarks

This review makes apparent the need for multiple goals for teaching higher order thinking skills that include the explicit goal of teaching for transfer of the skills to a variety of subject area domains. An important ingredient for promoting the likelihood of transfer is teaching skills, metacognitive awareness and strategies, conditional knowledge and attitudes as they relate to various subject matter areas, rather than relying on students to make such connections themselves (Alexander & Judy, in press). This requires careful examination of the extent to which general skills appropriately apply to different subject areas, and showing students how, for example, the skill of analysis in science--for example, identify the features of animate and inanimate objects--is similar to or different from the skill of analysis of literature--for example, identify the components of persuasive discourse (see Quellmalz, 1987). In addition, specific attention must be paid to helping students develop strategic knowledge and ability to manage their own learning and thinking.

From the available evidence, a clear choice does not emerge as to whether teaching thinking skills should take place in specific programs or as part of regular subject matter instruction. Instead, an argument has been advanced that particular features of programs are necessary if the likelihood of transferring skills beyond program exercises is to be increased. It was shown that many of the programs reviewed can be useful tools, but they need to be used in conjunction with occasions for students to develop and use higher order thinking in subject areas, and that students must be helped to see the connections between the skills and abilities taught in the programs and how they can be used in academic learning experiences and everyday reasoning.

References

Adams, M. (1986). Teaching thinking to Chapter 1 students. Paper prepared for the Conference on Alternative Designs in Compensatory Education, Washington D.C.

Alexander, P.A., & Judy, J.E. (in press). The interaction of domain-specific and strategic knowledge in academic performance. Review of Educational Research.

Barbieri, E.L. (1988). Talents Unlimited: One school's success story. Educational Leadership, 45(7), 35.

Baron, J.B. (1987). Evaluating thinking skills in the classroom. In J.B. Baron & R.J. Sternberg (Eds.), Teaching thinking skills: Theory and practice (pp. 221-247). New York: Freeman.

Black, J.G., Swan, K., & Schwartz, D.L. (1988). Developing thinking skills with computers. Teachers College Record, 89, 384-407.

Brandt, R. S. (Eds.). (1988). Teaching thinking throughout the curriculum. Educational Leadership, 45(7).

Bransford, J.D., Arbitman-Smith, R., Stein, B.S., & Vye, N.J. (1985). Improving thinking and learning skills: An analysis of three approaches. In J.W. Segal, S.F. Chipman, & R. Glaser (Eds.), Thinking and learning skills: Vol. 1. Relating instruction to research (pp. 133-208). Hillsdale, NJ: Erlbaum.

Bransford, J.D., Burns, M.S., Delclos, V.R., & Vye, N.J. (1986). Teaching thinking: Evaluating evaluations and broadening the data base. Educational Leadership, 44(2), 68-70.

Brown, A.L., & Palincsar, A.S. (1985). Reciprocal teaching of comprehension strategies: A natural history of one program for enhancing learning (Tech. Rep. No. 334). Urbana: University of Illinois, Center for the Study of Reading.

Chance, P. (1986). Thinking in the classroom. New York: Teachers College Press.

Covington, M.V. (1985). Strategic thinking and the fear of failure. In J.W. Segal, S.F. Chipman, & R. Glaser (Eds.), Thinking and learning skills: Vol. 1. Relating instruction to research (pp. 389-416). Hillsdale, NJ: Erlbaum.

Crump, W.D., Schlichter, C.L., & Palk, B.E. (1988). Teaching HOTS in the middle and high school: A district-level initiative in developing higher order thinking skills. Roeper Review, 10(4), 205-211.

deBono, E. (1985). The CoRT thinking program. In J.W. Segal, S.F. Chipman, & R. Glaser (Eds.), Thinking and learning skills: Vol. 1. Relating instruction to research (pp. 363-388). Hillsdale, NJ: Erlbaum.

Emihovich, C., & Miller, G. (1988). Learning logo: The social context of cognition. Journal of Curriculum Studies, 20, 57-70.

Feuerstein, R., Jensen, M., Hoffman, M.B., & Rand, Y. (1985). Instrumental enrichment, an intervention program for structural cognitive & modifiability: Theory and practice. In J.W. Segal, S.F. Chipman, & R. Glaser (Eds.), Thinking and learning skills: Vol. 1. Relating instruction to research (pp. 43-82). Hillsdale, NJ: Erlbaum.

Guilford, J.P. (1967). The nature of human intelligence. New York: McGraw-Hill.

Herrnstein, R.J., Nickerson, R.S., deSanchez, M., & Swets, J.A. (1986). Teaching thinking skills. American Psychologist, 41, 1279-1289.

Hobbs, D.E. (1988). Talents Unlimited: A thinking skills model that works: Leadership News, 14(4).

Kirschner, B.W., Raphael, T.E., & Englert, C.S. (1986, April). Collaboration in writing: The transfer of control from researcher to teacher and from teacher to students. Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Lerher, R. (1986). Logo as a strategy for developing thinking? Educational Psychologist, 21, 121-137.

Lipman, M. (1985). Thinking skills fostered by philosophy for children. In J.W. Segal, S.F. Chipman, & R. Glaser (Eds.), Thinking and learning skills: Vol. 1. Relating instruction to research (pp. 83-108). Hillsdale, NJ: Erlbaum.

Lipman, M. (1987). Some thoughts on the foundations of reflective education. In J.B. Baron & R.J. Sternberg (Eds.), Teaching thinking skills: Theory and practice (pp. 151-161). New York: Freeman.

Newman, D. (1985). Functional environments for microcomputers in education. The Quarterly Newsletter of the Laboratory of Comparative Human Cognition, 7(2), 51-57.

Nickerson, R.S., Perkins, D.N., & Smith, E.E. (1985). The teaching of thinking. Hillsdale, NJ: Erlbaum.

Nix, D. (1988). Should computers know what you can do with them? Teachers College Record, 89, 418-430.

Palincsar, A.M. (in press). The role of dialogue in providing scaffolded instruction. Educational Psychologist.

Palincsar, A.M., & Brown, A.L. (1985). Reciprocal teaching: Activities to promote "reading with your mind." In T.L. Harris & E.J. Cooper (Eds.), Reading, thinking, and concept development (pp. 147-158). New York: College Entrance Examination Board.

Papert, S. (1980). Mindstorms. New York: Basic Books.

Pea, R.D., & Kurland, D.M. (1984). Logo programming and the development of planning skills (Tech. Rep. No. 16). New York: Bank Street College of Education, Center for Children and Technology.

Pearson, P.D., & Dole, J.A. (1987). Explicit comprehension instruction: A review of research and a new conceptualization of instruction. Elementary School Journal, 88, 151-165.

Polson, P.G., & Jeffries, R. (1985). Instruction in general problem-solving skills: An analysis of four approaches. In J.W. Segal, S.F. Chipman, & R. Glaser (Eds.), Thinking and learning skills: Vol. 1. Relating instruction to research (pp. 417-458). Hillsdale, NJ: Erlbaum.

Prawat, R. (1988). Promoting access: The role of organization and awareness factors (Elementary Subjects Center Series No. 1). East Lansing: Michigan State University, Institute for Research on Teaching, Center for the Learning and Teaching of Elementary Subjects.

Pressley, M., Cariglia, T., & Snyder, B.L. (1985). Are there programs that can really teach thinking and learning skills? [Review of Segal, Chipman, & Glaser's Thinking and learning skills: Vol. 1. Relating instruction to research.] Unpublished paper, Department of Psychology, University of Western Ontario, London, Canada.

Quellmalz, E.S. (1987). Developing reasoning skills. In J.B. Baron & R.J. Sternberg (Eds.), Teaching thinking skills: Theory and practice (pp. 86-105). New York: Freeman.

Raphael, T.E., Englert, C.S., & Kirschner, B.W. (1986). The impact of text structure instruction and social context on students' comprehension and production of expository text (Research Series No. 177). East Lansing: Michigan State University, Institute for Research on Teaching.

Raphael, T.E., & Kirschner, B.W. (1985). Improving expository writing ability: Integrating knowledge of information sources and text structures (Research Series No. 161). East Lansing: Michigan State University, Institute for Research on Teaching.

Raphael, T.E., Kirschner, B.W. & Englert, C.S. (1986a). Students' metacognitive knowledge about writing (Research Series No 176). East Lansing: Michigan State University, Institute for Research on Teaching.

Raphael, T.E., Kirschner, B.W. & Englert, C.S. (1986b). Text structure instruction within process-writing classrooms: A manual for instruction (Occasional Paper No. 104). East Lansing: Michigan State University, Institute for Research on Teaching.

Reeve, R.A., Palincsar, A.M., & Brown, A.L. (1987). Everyday and academic thinking: implications for learning and problem solving. Journal of Curriculum Studies, 19, 123-133.

Resnick, L.B. (1987). Education and learning to think. Washington, DC: National Academy Press.

Savell, J.M., Twohig, P.T., & Rachford, D.L. (1986). Empirical status of Feuerstein's "Instrumental Enrichment" (FIE) technique as a method of teaching thinking skills. Review of Educational Research, 56, 381-409.

Schlichter, C.L. (1981). The multiple talent approach in mainstream and gifted programs. Exceptional Children, 48, 144-150.

Schlichter, C.L. (1986). Talents Unlimited: An inservice education model for teaching thinking skills. Gifted Child Quarterly, 30, 119-123.

Schlichter, C.L., Hobbs, D., & Crump, W.D. (1988). Extending Talents Unlimited to secondary schools. Educational Leadership, 45(7), 36-40.

Sternberg, R.J. (1987). Questions and answers about the nature and teaching of thinking skills. In J.B. Baron & R.J. Sternberg (Eds.), Teaching thinking skills: Theory and practice (pp. 251-260). New York: Freeman.

Sternberg, R.J., & Bhana, K. (1986). Synthesis of research on the effectiveness of intellectual skills programs: Snake-oil remedies or miracle cures? Educational Leadership, 44(2), 60-67.

Swan, K., & Black, J.B. (undated). The cross-contextual transfer of problem solving skills (CCT Report 87-3). New York: Columbia University.

Taylor, C.W. (1967). Questioning and creating: A model for curriculum reform. Journal of Creative Behavior, 1, 22-23.